RE-ORDER NO. 65-1042

TEST REPORT FOR
JET PROPULSION LABORATORY
MINIATURE TRANSFORMERS
PROCEDURE 902.35-04

SUBMITTED BY

DRESSER HST
ENVIRONMENTAL LABORATORY

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, pursuant to a subcontract issued under Prime Contract NAS7-100 between the California Institute of Technology and the United States of America represented by the National Aeronautics and Space Administration.

Final Report

on

Test Program

902.35-01

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by

Author Charles E. Smith

on

Contract Number 950893

Job Number 05349

Approved by

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555 N. Fifth Street
Garland, Texas

Abstract

This report contains the results of tests performed on a group of miniature transformers listed below. Tests were performed per JPL Test Procedure No. 902.35-01: Test Specification, Electronic Component Parts Reliability, Transformer, Miniature, dated March 13, 1964.

Manufacturer	Manufacturer Part No.	Quantity
Microtran	PM7-M	15
Microtran	PM17-M	15
Triad	SP-5	15
Triad	SP-66	15
UTC	DO-T10	15
UTC	DO-T36	15

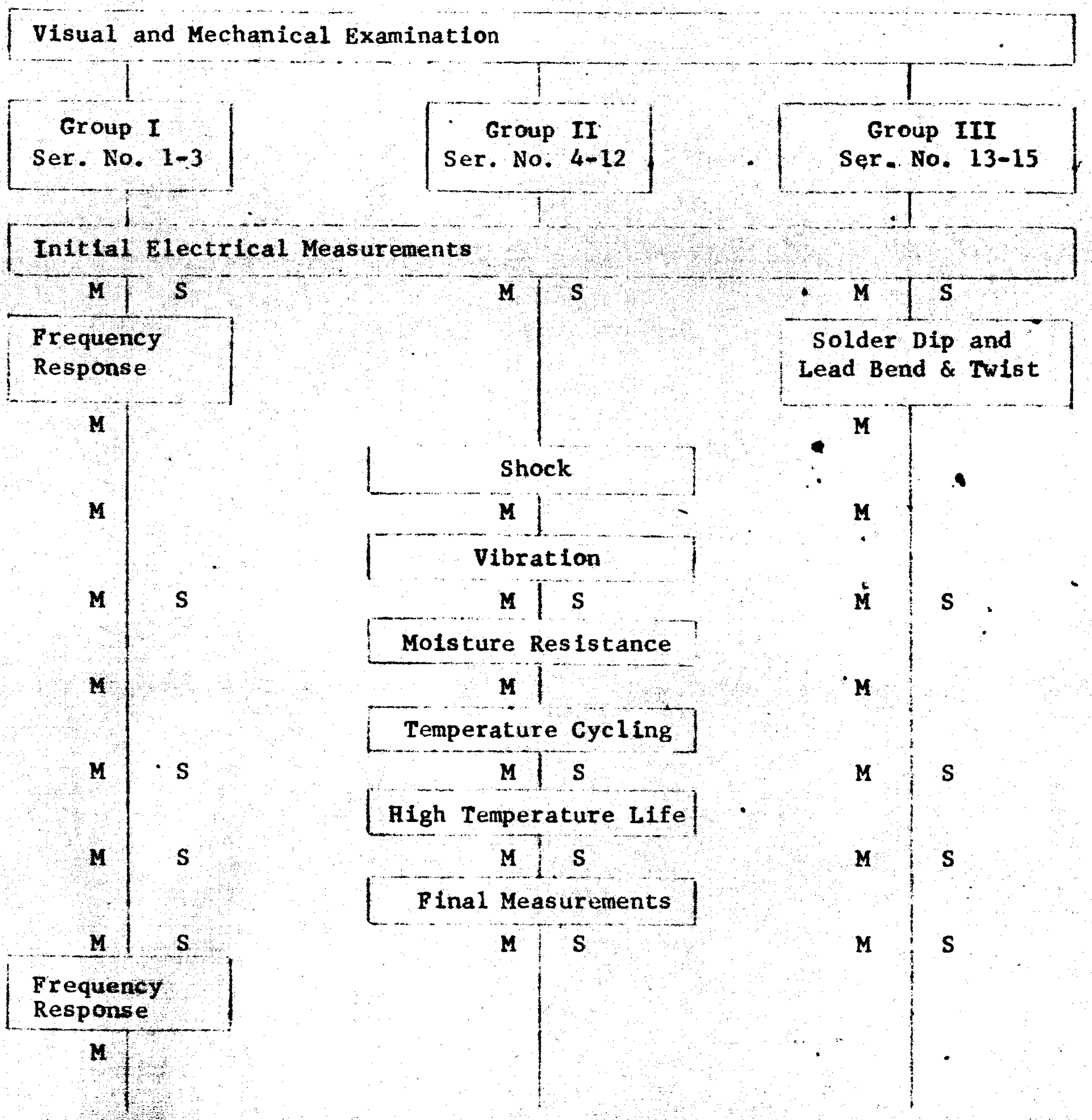
The parts were divided into three categories:

1.6 Hy	2.0 Hy	8.0 Hy
Microtran PM17-M	UTC DO-T36	Microtran PM7-M
Triad SP-66		Triad SP-5
UTC DO-T10		

The purpose of the test program was to qualify the above parts, and to establish their reliability with respect to vendor type and/or environmental condition.

The units were serialized from 1-15 and divided into three groups. Transformers with serial numbers 1-3 were placed in Group I. Transformers numbered from 4-12 were placed in Group II. Transformers numbered from 13-15 were placed in Group III. The test sequence was performed in accordance with the flow chart on next page. These tests were performed in accordance with the applicable paragraphs of JPL Spec. 902.35-01.

Flow Chart



M = measurement data point

S = submittal point for complete CSS (Computed Statistics Sheet) to be submitted in bound form with cover and index.

Brief results of each electrical measurement point are listed below.

Initial Electrical Measurements

One each of Microtran PM17-M and Triad SP-66 failed the Dielectric Withstanding Voltage test. One unit of Triad SP-66 had a small crack on one side.

Frequency Response

All units showed satisfactory results.

Solder Dip

The insulation on leads of the UTC units melted, further testing of this type discontinued. Microtran and Triad units had satisfactory coating.

Lead Bend and Twist

Three units of Microtran PM7-M failed twist test.
Three units of Microtran PM17-M failed twist test.

Shock

No evidence of physical or electrical damage.

Vibration

No evidence of physical damage.
One unit of UTC DO-T36 had 4K megohms on Insulation Resistance Between windings.

Moisture Resistance

All Triad units had evidence of slight corrosion on leads. No evidence of any other physical damage.
One unit of Microtran PM7-M, two units of Triad SP-5, seven units of UTC DO-T10, and 6 units of UTC DO-T36 had low insulation resistance (less than 6K megohms).
Two units of Microtran PM7-M and three units of Microtran PM17-M failed the Dielectric Withstanding Voltage Test.

Temperature Cycling

One unit of UTC DO-T10 had a yellow substance come out at the bottom of the unit at outer edge. Substance appears to be uncured #56 tape.

One unit of UTC DO-T36 had a light brown substance come out on side of unit, near top of the can. Substance appears to be uncured impregnation. No evidence of any further physical damage.

High Temperature Life

One unit of Triad SO-66 had open secondary on DCR after 168 hour life test. One unit of Microtran PM17-M had lead break off during 1000 hour life test. One unit of Microtran PM7-M had lead break off during 1500 hour life test. One unit of UTC DO-T36 failed on inductance after 1500 life test.

No evidence of any further physical damage.

Summary

Of the 90 units that began the tests, 17 failed to complete tests. These units and probable cause of failure are listed below.

Microtran	Ser. No.	Failure
PM7-M	013	Open
	014	Open
	015	Open
	002	Dielectric Withstanding
	008	Dielectric Withstanding
	012	Broken Lead
PM17-M	003	Dielectric Withstanding
	013	Open
	014	Open

Microtran	Ser. No.	Failure
	015	Open
	005	Dielectric Withstanding
	008	Dielectric Withstanding
	010	Dielectric Withstanding
	007	Broken Lead

Triad	Ser. No.	Failure
SP-66.	006	Dielectric Withstanding
	001	Open

UTC	Ser. No.	Failure
DO-T36		Inductance

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Appendix

1.0 Introduction

This report covers results of Qualification Tests performed by Dresser-HST Environmental Laboratory, 555 N. Fifth Street, Garland, Texas, on parts supplied by the Jet Propulsion Laboratories, 4000 Oak Grove Drive, Pasadena, California.

The tests performed were those defined in JPL Specification 902. 35-01, Test Specification Electronic Component Parts Reliability, Transformers, Miniature, dated 13 March 1964. The test period extended from September 1964 to April 1965. Results obtained by the tests are not intended by the tests facility to specify either acceptance on non-acceptance of any particular part. Results given must be weighed with the desired reliability for a particular application for which the part is to be used.

2.0 Description of Test Items

Vendor	Part No.	Primary Inductance	Center Tap PRI	Center Tap SEC	Turns Ratio PRI		Turns Ratio SEC	DCR (Ohms) PRI	DCR (Ohms) SEC	Power Level (MW)	Size
Microtran	PM7-M	26.0 HY	X	X	7.07	:	1.0	3300	75	10	.465 x .401 x .310
Microtran	PM17-M	5.0 HY	X	X	1.0	:	1.0	1000	75	50	
Triad	SP-5	26.0 HY	X	X	7.07	:	1.0	3800	75	25	.465 x .410 x .310
Triad	SP-66	5.0 HY	X	X	1.0	:	1.0	1000	1300	50	
UTC	DO-T10	1.6 HY		X	2.89	:	1.0	780	115	100	.407 x .312
UTC	DO-T36	2.0 HY	X	X	1.0	:	1.0	975	1175	100	

3.0 Description of Test Program

3.1 Test Design

The test program required 90 units, 15 of each manufacturer's part type. Each unit was serialized from 001-015 and catagorized into three groups.

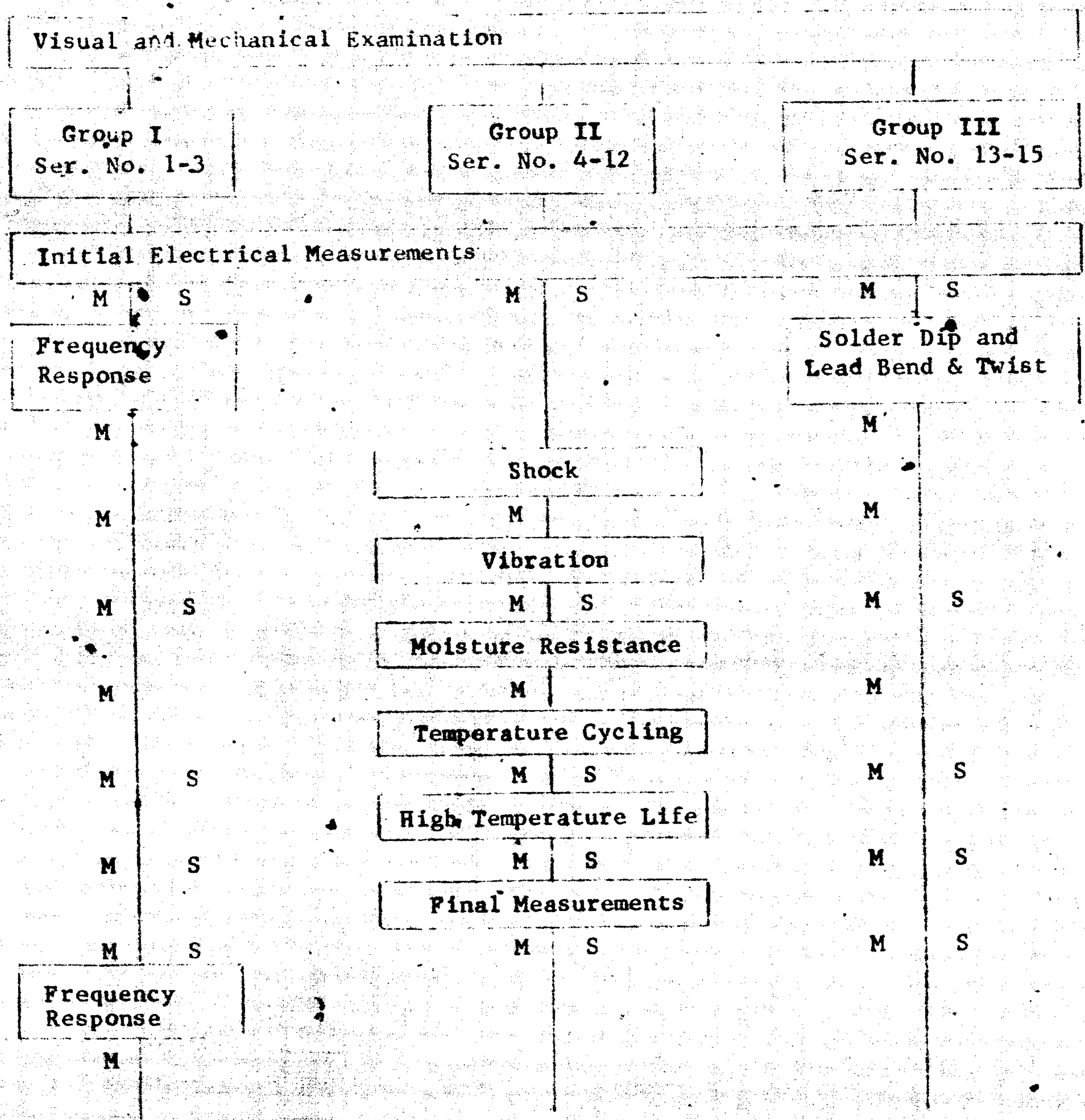
Group I - Control Group - Nos. 1-3

Group II - Climatic Group - Nos. 4-12

Group III - Physical-Climatic Group - Nos. 13-15

The flow chart on the next page depicts the tests performed on each group and the measurement points.

Flow Chart



Visual and Mechanical Examination
Group I
Ser. No. 1-3
Group II
Ser. No. 4-12
Group III
Ser. No. 13-15
Initial Electrical Measurements
M
S
Frequency
Response
Solder Dip and
Lead Bend & Twist
Shock
Vibration
Moisture Resistance
Temperature Cycling
High Temperature Life
Final Measurements
Frequency
Response

3.2 Measurement Procedures

3.2.1 D. C. Resistance

3.2.1.1 Test Equipment

Cimron Digital VOM Model 7200A, Serial No. 3037, Accuracy ±.02%.

3.2.1.2 Procedure (Ref. Para. 4.2.2.1 and 4.5.1 of JPL Spec. 902.35-01)

The units were tested at normal room temperature of 60°-74°F. Connections were made by a clamping fixture and measurements made and recorded to five (5) places.

3.2.2 Primary Inductance

3.2.2.1 Test Equipment

Cimron Digital VOM Model 7200A, Serial No. 3037, Accuracy ±.02%; ESI Bridge Model 250-DA, Serial No. S-0010, Accuracy ±3%; Sensitive Research Milliammeter, University Model, Serial No. 1035, Accuracy ±1%; Heath Audio Signal Generator Model AG-10, Serial No. 0865, Calibrated to within ±2 cps on each use.

3.2.2.2 Procedure (Ref. Para. 4.2.2.2 and 4.5.2 of JPL Spec. 902.35-01)

The units were mounted in a test fixture and inductance was measured at 5V rms, 1000 cps with the D.C. current specified in Table II of JPL Spec. 902.35-01. Primary Inductance was measured across the total winding and recorded to four (4) places.

3.2.3 Turns Ratio (Pri:Sec)

3.2.3.1 Test Equipment

Cimron Digital VOM Model 7200A, Serial No. 3037, Accuracy ±.02%; Hewlett-Packard Audio Signal Generator Model 200CD, Serial No. 1088, Accuracy ±2 cps; Beckman Counter Model 7150B, Serial No. 0240; Hewlett-Packard VTVM Model 400H, Serial No. 0846, Accuracy ±3%; Heath Decade Resistance Box Model DR-1, Serial No. 0629, Accuracy ±1%.

3.2.3.2 Procedure (Ref. Para. 4.2.2.3 and 4.5.3 of JPL Spec. 902.35-01)

A potential of 10V rms at 1000 cps was applied to the specimen primary with the secondary unloaded. Primary and secondary voltages were measured three (3) times. The turns ratio was then calculated using the averages of the voltage measurements with a secondary value of 1.00.

3.2.4 Center Tap Unbalance

3.2.4.1 Test Equipment

Equipment used was same as for Turns Ratio test, see para. 3.2.3.1 of this report.

3.2.4.2 Procedure (Ref. Para. 4.2.2.4 and 4.5.4 of JPL Spec. 902.35-01)

A potential of 10V rms at 1000 cps was applied to the primary with the secondary loaded as per Table II of JPL Spec. 902.35-01. The voltage induced in the two halves of both primary and secondary windings was measured three (3) times and the average reading was calculated and recorded. The percentage of unbalance was then calculated as follows:

$$C.T.U. = \frac{E_1 - E_2}{E_1} \times 100\%$$

where E_1 is the larger value.

3.2.5 Insulation Resistance

3.2.5.1 Test Equipment

Industrial Instruments Megohmmeter Model L-7, Serial No. 0194, calibrated before each use to ±4%.

3.2.5.2 Procedure (Ref. Para. 4.2.2.5 and 4.5.5 of JPL Spec. 902.35-01)

The unit was held securely on two sides by a metallic clamp which served as a connection point for one side of the potential during tests between windings and case. A potential of 100V D.C. was applied for a minimum of 30 seconds between windings and between windings and case.

3.2.6 Dielectric Withstanding Voltage

3.2.6.1 Test Equipment

Associated Research Test Set Model 412, Serial No. 0182, Accuracy ±3%.

3.2.6.2 Procedure (Ref. Para. 4.2.2.6 and 4.5.6 of JPL Spec. 902.35-01)

A 60 cycle test potential was applied at a rate of 100V rms per second to the value specified in Table II of JPL Spec. 902.35-01 between each winding and between windings and case for a period of 15-20 seconds. A metallic clamp was used to insure good contact with two or more surface areas of the case while testing dielectric strength between windings and case.

3.2.7 Frequency Response

3.2.7.1 Test Equipment

Hewlett-Packard Audio Signal Generator Model 200DC, Serial No. 1088, Accuracy ±2cps; Beckman Frequency Counter Model 7150B, Serial No. 0240; Hewlett-Packard VTVM Model 400H, Serial Nos. 0846 and 0847, Accuracy ±3%; Hewlett-Packard Oscilloscope Model 122A, Serial No. 0648; McIntosh Amplifier Model MI-75, Serial No. 1179; Heath Decade Box Model DR-1, Serial Nos. 0149 and 0629, Accuracy ±1%.

3.2.7.2 Procedure (Ref. Para. 4.2.2.7 and 4.5.7 of JPL Spec. 902.35-01)

The load resistances for the various parts were assembled using carbon resistors and a Leeds & Northrup Wheatstone Bridge. These resistances were used for initial and all subsequent measurements. The secondary windings were then loaded with the specified resistance and a signal generator output at 1000 cps (E_s) was applied and increased to produce the desired secondary voltage (V_o) as specified in Table II of JPL Spec. 902.35-01. The measured E_s was then taken as the 0 db reference level. The frequency of the signal generator was then adjusted to .3K, .5K, .75K, 1K, 5K, 10K, 25K, 50K, 75K and 100K cps. At each new frequency the E_s was adjusted to provide the required secondary voltage and the value of E_s was recorded. Distortion was observed on a dual trace scope. Frequency response was then calculated in db using E_s as a reference voltage and recorded changes in E_s at frequencies mentioned previously and the formula:

$$db = 20 \log \frac{E_r}{E_f}$$

where: E_r = output reference voltage at 1000 cps

E_f = output voltage at specified frequency.

3.3 Environmental Test Procedures

3.3.1 Solder Dip

3.3.1.1 Test Equipment

Gray Instruments Potentiometer Model E3067, Serial No. 0813, Accuracy ±.05 MV. Solder Pot, Dee Electric Co. Model 12; 300 watt HST Environmental Lab Solderability test fixture (a motor driven dipping device designed per figure 208-1, Method 208A, MIL-STD-202C).

3.3.1.2 Procedure (Ref. Para. 4.2.4.1 JPL Spec. 902.35-01)

The solder pot was maintained at a temperature of 350°C ±10°C. The units were attached to the dipping device and the motor speed adjusted so as to immerse the leads into the solder to within 1/4 ±1/16 inches of the body and allowed to dwell in the solder for 3 seconds. The units were then removed from the fixture and examined for softening of the insulation material and other possible damage.

3.3.2 Terminal Pull and Twist

3.3.2.1 Test Equipment

Five pound Healthways Weight Certified 10-29-58, Accuracy ±1 oz.

3.2.2.2 Procedure (Reference Para. 4.2.4.2 JPL Spec. 902.35-01)

(a) Terminal pull - The transformer body was attached to a fixed point and a 5 pound weight was gradually applied to the end of each wire lead in a line along the longitudinal axis of the lead. This weight was maintained for a minimum of 10 seconds.

(b) Terminal twist - Each unit was clamped in a fixed position and its leads were bent to an angle of 90° 1/4 of an inch from the transformer body. Each lead was then rotated first clockwise and then counter-clockwise 360° three times. At completion of tests all units were inspected for physical damage. DCR and IR were measured and recorded upon completion of these tests.

3.3.3 Mechanical Shock

3.3.3.1 Test Equipment

AVCO Shock Machine Type SM-020, Model 1, Serial No. 1009. Columbia Research Lab. Cathode Follower, Model #4000, Serial No. 1516. Endevco Accelerometer, Model 2215, Serial No. AJ00. Tektronix Scope Type 545, Serial No. 13412.

3.3.3.2 Procedure (Ref. Para. 4.3.2 JPL Spec. 902.35-01)

The parts were rigidly mounted on an aluminum test fixture and subjected to five shock blows in each of three directions. One series (5) in the longitudinal axis of the lead. One series (5) in the reverse direction of the above series. One series (5) in a plane perpendicular to the axis of the above two series. The units were non-energized during the test. Primary Inductance, IR, and DCR were measured and recorded upon completion of the test.

3.3.4 Vibration

3.3.4.1 Test Equipment

M.B. 3500 force lb. Auto Cycle Vibration System

(a) M.B. Exciter, Model C-25-H, Serial No. 462

(b) M.B. Amplifier, Model T666, Serial No. 214

(c) M.B. Control Console, Model N572-73, Serial No. 288

3.3.4.2 Procedure (Ref. Para. 4.3.3 JPL Spec. 902.35-01)

The units were rigidly mounted to the same fixture used for the shock test and were subjected to a vibration having a sinusoidal wave with peak amplitude of 20g's. The frequency was varied from 30 cps to 2000 cps and back to 30 cps in twenty minutes. This cycle was repeated five times in each of two axis. One axis being the longitudinal axis of the leads, the other being along an axis perpendicular to the above axis. The units were non-energized. Primary Inductance, IR, and DCR were measured upon completion of the test.

3.3.5 Moisture Resistance

3.3.5.1 Test Equipment

Conrad Temperature Humidity Chamber Model FD-36-3, Serial No. 7150.

3.3.5.2 Procedure (Ref. Para. 4.3.4 JPL Spec. 902.35-01)

This test was performed per MIL-STD-202B Method 106-1. The transformers were subjected to ten continuous 24 hour cycles as shown by M.R. charts in appendix. No polarizing voltage was applied. The transformers were mounted on a nylon mesh streched across an aluminum chassis. Primary Inductance, IR, DCR, Turns Ratio, and Dielectric Withstanding Voltage measurements were made upon completion of test.

3.3.6 Temperature Cycling

3.3.6.1 Test Equipment

Two Conrad Temperature Chambers Model FB-32-3-3, Serial Nos. 7669 and 7670.

3.3.6.2 Procedure (Ref. Para. 4.3.1 JPL Spec. 902.35-01)

The temperature chambers were set at $-55°C\ ^{+3°}_{-0°}$ and $125°C\ ^{+0°}_{-3°}$ respectively. The non-energized units were then subjected to five continuous cycles. One cycle consisted of:

Step	Temperature	Time at Temperature
1	-55°C	30 minutes
2	Room	5 minutes max
3	+125°C	30 minutes
4	Room	5 minutes max

Upon completion of test the units were allowed to stabilize at room ambient overnight. Primary Inductance, IR, and DCR were then measured.

3.4 Life Test Procedures

3.4.1 Test Equipment

Blue M Oven Model POM-5886C, Serial No. PA413 Cimron Digital VOM Model 7200A, Serial No. 3037, Accuracy ±.02%; Industrial Instruments Megohmmeter Model L-7, Serial No. 0194; Hewlett-Packard Oscilloscope Model 200CD, Serial No. S-0055; Beckman Frequency Counter Model 7150B, Serial No. 0240; ESI Bridge Model 250DA, Serial No. S-0010, Accuracy ±1%; Sensitive Research Milliammeter, University Model, Serial No. 1035, Accuracy ±1%; Cimron OHMS-DC Converter, Model 6911A, Serial No. 0904: Cimron AC-DC Converter, Model 6701A, Serial No. 0902.

3.4.2 Procedure (Ref. Para. 4.3.5.1 JPL Spec. 902.35-01)

The oven was stabilized at $105°C^{+0°}_{-4°}$. The units were divided into two groups. Group I consisted of the 0 ma D.C. units (Microtran PM7-M, Triad SP-5 and UTC DO-T36). Group II consisted of the 1 ma D.C. units (Microtran PM17-M, Triad SP-66 and UTC DO-T10). The non-energized units were mounted on a fiber glass mesh and placed in the oven. The life test consisted of 2000 continuous hours at this temperature, with the exception of the data measurement points at 168, 500, 1000, 1500 and 2000 hours. The schedule was arranged so that the data measurements were recorded within an eight hour period. When the units were removed from the oven for measurements, they were allowed to stabilize at room ambient (25°C) for 2 hours before the tests were started. Approximately five hours were required to complete the tests. The seven hours spent out of the oven were counted as part of the 2000 hour total. Measurements made at each period were Primary Inductance, IR and DCR.

3.4.3 Final Measurements

Upon completion of the 2000 Hour Life Tests the units were again tested for DCR (primary and secondary), Primary Inductance, Turns Ratio, C.T.U., IR, Dielectric Withstanding Voltage, and Frequency Response.

3.5 Data Recording and Verification Procedures

3.5.1 Recording of Data

All data were recorded manually on JPL Form 1494. The recorded data were reviewed by the Project Manager after each measurement point; all trends, failures, etc. were watched closely for possible errors in recording. This information was then processed onto IBM data cards by CEIR, Beverly Hills, California.

3.5.2 Verification Procedures

The same electrical test equipment was used throughout the test program in order to exclude possible errors in electrical measurements that would arise from using different test equipment. After each measurement point of a group, a random sample equal to 5% of the group was taken by a technician, other than the one who made the initial measurement, and this sample was retested by the second technician in order to verify the first technician's recordings. The second technician also checked out the test set-up for correctness and conformance to the previous test set-ups. After all data were recorded and verified by the technician, the data were reviewed by the Project Manager. This review included a comparison with previous test readings, limits of parameters, neatness and legibility, and correctness of data heading.

3.6 Failure Verification and Analysis Procedure

Whenever a failure occurred the Project Manager performed a retest to verify that the part, or parts, were actual failures. If and when the failure was verified the part, and all pertinent information relating to it, was placed in a sealed envelope. Each failure, by group, code, and serial number, was noted in the log book along with the cause (if known) of the failure. Each failure was subjected to a detailed failure analysis by the Project Manager, who was very familiar with the construction and manufacturing methods of the part, and with the test equipment used in the failure analysis.

Equipment available was:

(1) 7X to 120X Microscope.

(2) Hi Speed Roto-Tool and small drills.

(3) Electronic Test Equipment of various types.

(4) Miscellaneous hand tools.

All internal failures were carefully analyzed by removing the potting compound by hand, under the microscope. Photographs of failures were made (using a Bausch & Lomb Model N Camera with Polaroid back) along with a detailed written explanation of the cause of failure.

4.0 Test Results

4.1 Catastrophic Failures

For the purpose of this report, a catastrophic failure shall be defined as -- any transformer exhibiting an open or shorted condition or IR value of less than 10 megohms. (Reference Para. 4.3.6.2 JPL Spec. 902.35-01) The listing below is arranged by group and test point with all failures noted after each test point.

4.1.1 All Units

A. Visual and Mechanical Inspection

1. Triad SP-66, Serial No. 014 had small crack on side of unit.

B. Initial Electrical Measurements

1. Microtran PM17-M, Serial No. 003 failed Dielectric Withstanding Voltage test. Internal inspection revealed an insulation breakdown between windings.
2. Triad SP-66, Serial No. 006 failed Dielectric Withstanding Voltage test. Cause of failure undetermined.

4.1.2 Group One - Serial Nos. 001-003

A. Frequency Response - None

B. Shock - None

C. Vibration - None

D. Moisture Resistance

1. Microtran PM7-M, Serial No. 002 failed the Dielectric Withstanding Voltage test. The unit failed at 220V. An internal inspection revealed that the insulating tape between primary and secondary was stretched too tight and the wires cut thru the tape.

E. Temperature Cycling - None

F. High Temperature Life

1. Triad SP-66, Serial No. 001 showed an open on Secondary DCR after 168 hour life. Cause undetermined.

4.1.3 Group Two - Serial Nos. 4-12

A. Shock - None

B. Vibration - None

C. Moisture Resistance

1. Microtran PM7-M, Serial No. 008 failed Dielectric Withstanding Voltage test. The unit failed at 50V.
2. Microtran PM17-M, Serial Nos. 005, 008 and 010 failed Dielectric Withstanding Voltage test. The units failed at approximately 275V.

D. Temperature Cycling

1. UTC DO-T10, Serial No. 006 had a yellow substance come out at the bottom of the unit at outer edge. Substance believed to be uncured #56 tape. The unit was still functional and was not classified as a failure.
2. UTC DO-T36, Serial No. 001 had a light brown substance come out on side near the top of the can. Substance believed to be uncured impregnation. The unit was still functional and was not classified as a failure.
3. UTC DO-T36, Serial No. 012 had one half of green secondary lead to break off (due to handling) during DCR measurement. The unit was still functional, was not classified as a failure, and remained on test.

E. High Temperature Life

1. Microtran PM17-M, Serial No. 007 primary lead (terminal #1) broke off during primary inductance measurements on 1000 hour life test.
2. Microtran PM7-M, Serial No. 012 had lead (terminal #7) break off during 1500 hour life test.

4.1.4 Group Three

A.1 Solder Dip - None

A.2 Lead Pull and Twist

1. Microtran PM7-M, Serial Nos. 013, 014, and 015 had discontinuity between terminals 7 and 5 and 5 and 6, units had continuity between 4 and 6.

2. Microtran PM17-M, Serial No. 013, terminal #3 pulled loose, but did not separate from case, discontinuity existed between terminals 2 and 3, 4 and 5, and 5 and 6.

3. Microtran PM17-M, Serial No. 014, terminals #2 and #5 failed pull and twist test. (Spearated from unit.)

4. Microtran PM17-M, Serial No. 015, terminal #2 pulled free from unit, had discontinuity between terminals 4 and 5 and 5 and 6.

B. Shock - None

C. Vibration - None

D. Moisture Resistance - None

E. Temperature Cycling - None

F. High Temperature Life

1. 1500 Hour Life - UTC DO-T36, Serial No. 014, failed Primary Inductance. Could not set up proper input voltage level.

4.1.5 Summary Chart of Catastrophic Failures

Manufacturer	Part No.	Vis. Mech.	Init. Elec.	Freq. Response	Solder Dip & Lead Pull & Twist	Shock	Vib.	Mois. Res.	Temp. Cycle	Hi Temp. Life	Final Meas.
Microtran	PM7-M				3			2		1	
Microtran	PM17-M		1		3			3		1	
Triad	SP-5										
Triad	SP-66	1*	1							1	
UTC	DO-T10										
UTC	DO-T36									1	

*Unit had small crack on one side but successfully completed the test design.

4.2 Parametric Failures

Parametric failures are defined as follows: (Ref. Para. 4.6.3, 4.2.2 and Table I of JPL Spec. 902.35-01)

(a) DCR (primary and secondary) shall be ±25% of value in Table I.

(b) Primary Inductance shall be not less than the value in Table I.

(c) Turns Ratio shall be within ±5% of value in Table I.

(d) C.T.U. greater than 5%.

(e) IR less than 10 K Megohms.

(f) Dielectric Withstanding Voltage - as per Table I.

(g) Frequency Response shall be ±5 db from 200 to 100,000 cps.

(h) DCR change greater than 5%.

(i) Primary Inductance change greater than 15%.

(j) Turns Ratio change greater than 1%.

(k) IR measurement less than 117 Megohms.

4.2.1 Visual and Mechanical

4.2.1.1 Physical Appearance

One unit of Triad SP-66 had small crack on one side of unit, however the unit was electrically functional in all respects.

Nomenclature and legibility of all units was acceptable.

4.2.1.2 Physical Dimensions (Ref. Para. 4.2.1 and Table I of JPL Spec. 902.35-01)

No physical tolerances were given although it is assumed that they do exist. The following listing gives the min, mean and max physical dimensions of each unit type

1. Microtran PM7-M - .465 x .401 x .310
   - .465 dimension - .457, .462, .466
   - .401 dimension - .401, .404, .409
   - .310 dimension - .303, .304, .305
2. Microtran PM17-M - .465 x .401 x .310
   - .465 dimension - .454, .461, .463
   - .401 dimension - .403, .405, .407
   - .310 dimension - .303, .3044, .306

3. Triad SP-5 - .465 x .401 x .310

.465 dimension - .460, .461, .462

.401 dimension - .398, .399, .401

.310 dimension - .301, .303, .307

4. Triad SP-66 - .465 x .401 x .310

.465 dimension - .461, .4635, .471

.401 dimension - .391, .397, .401

.310 dimension - .299, .302, .306

5. UTC DO-T10 - .407 x .312

.407 dimension - .481, .503, .535

.312 dimension - .314, .331, .336

6. UTC DO-T36 - .407 x .312

.407 dimension - .462, .480, .495

.312 dimension - .331, .335, .346

4.2.2 Initial Electrical Measurements

A. Primary DCR - No failures

B. Secondary DCR - No failures

C. Primary Inductance

1. Microtran PM7-M, 3 units (20%) below the minimum acceptable value.

Serial No.	005	013	014
Reading	25.38	24.00	25.84

2. Microtran PM17-M, 14 units (93.3%) were below minimum acceptable value.

3. Triad SP-5, 4 units (26.7%) were below minimum acceptable value.

4. Triad SP-66, all units were below minimum acceptable value.

D. Turns Ratio - No failures

E. Center Tap Unbalance.

All units had a center tap unbalance of less than 5%.

F. Insulation Resistance - No failures

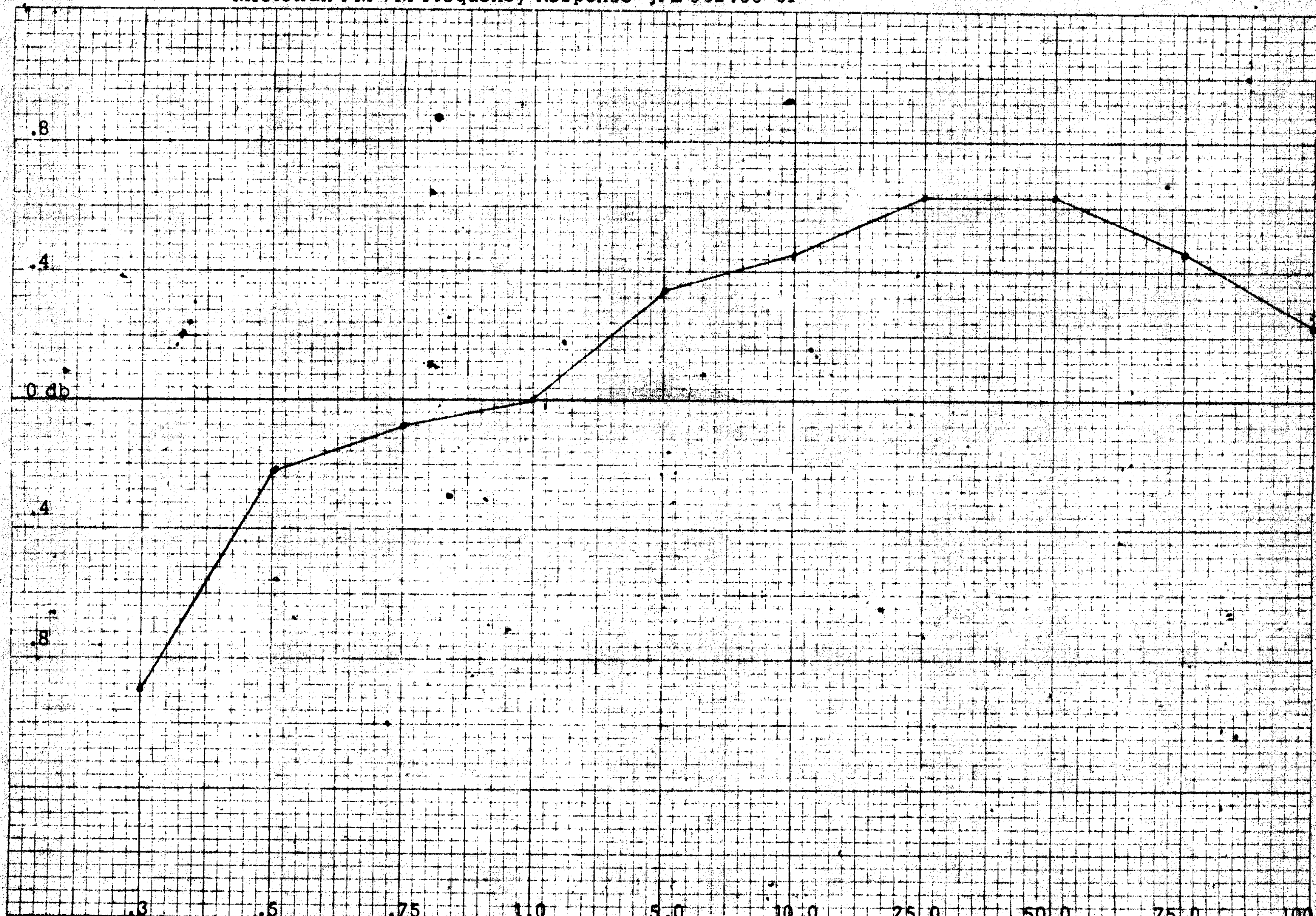
G. Dielectric Withstanding Voltage

1. Microtran PM17-M, Serial No. 003, failed.

2. Triad SP-66, Serial No. 006, failed. (See Para. 4.1.1 of this report.)

H. Frequency Response - No failures, the following six pages are frequency response charts for each vendor type.

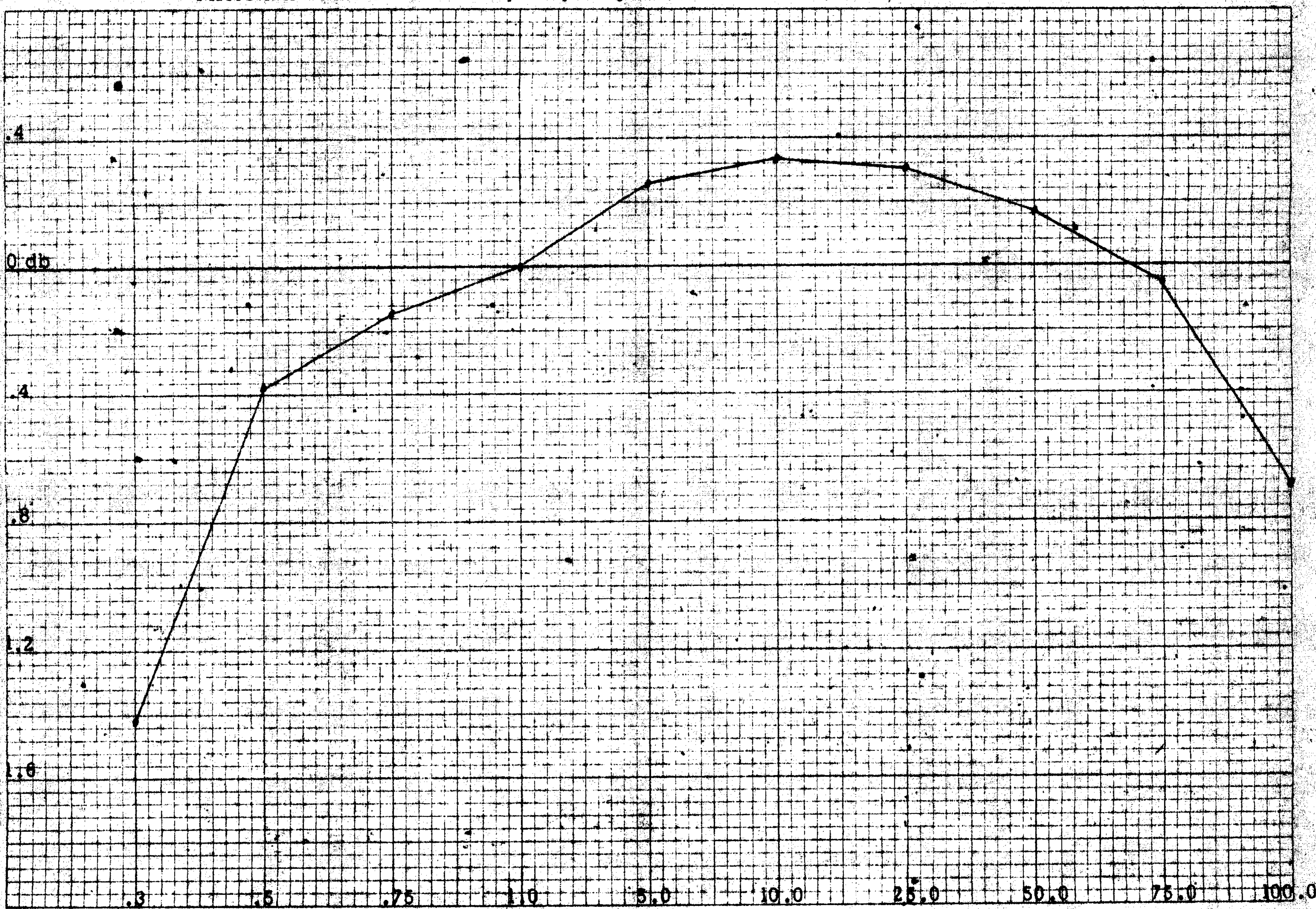
Mictotran PM 7M Frequency Response JPL 902.35-01



NO. 340R-10 DIETZGEN GRAPH PAPER 10 X 10 PER INCH

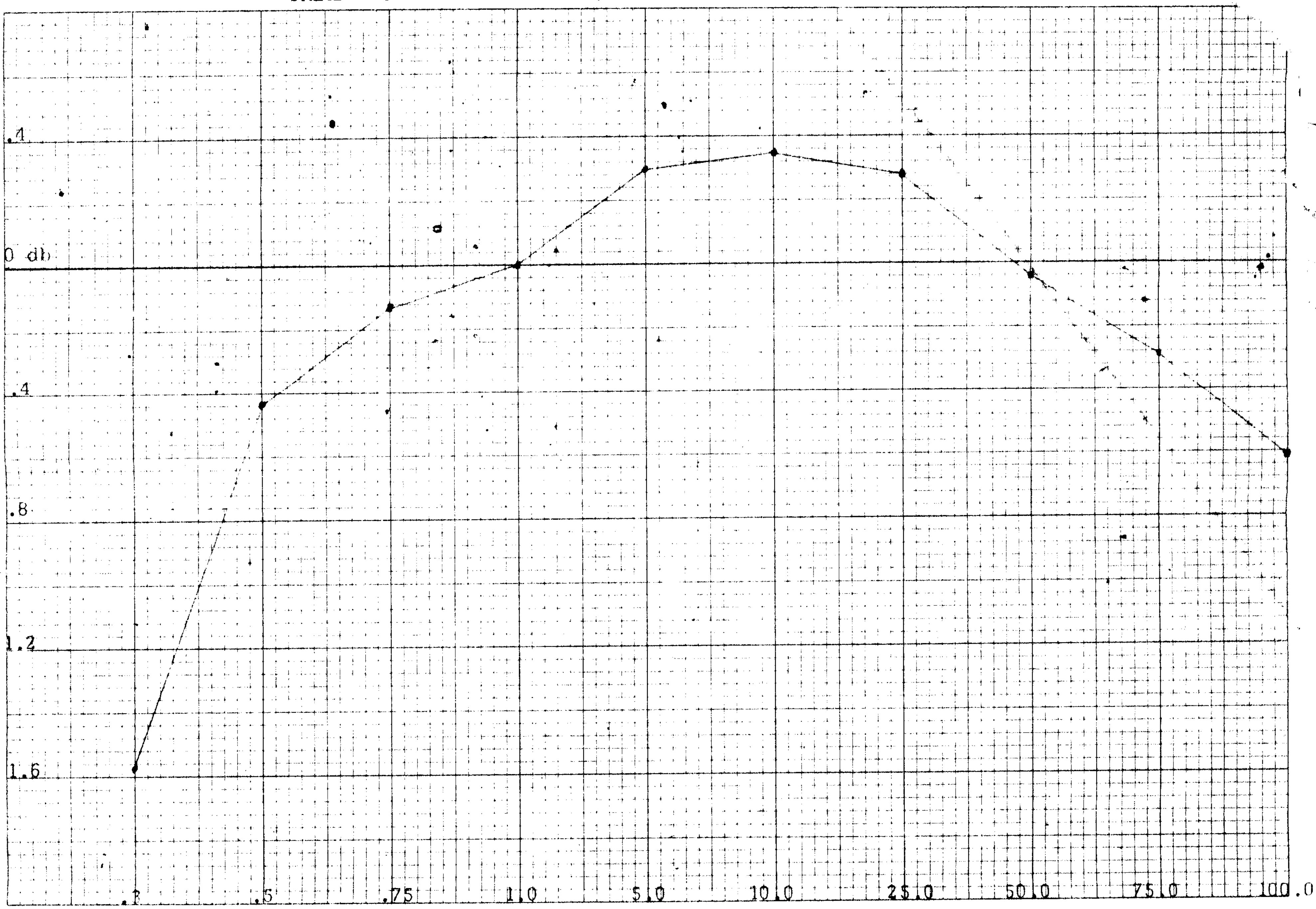
EUGENE DIETZGEN CO. MADE IN U. S. A.

Microtran PM17M Frequency Response JPL 902.35-01



TRIAD SP-5 FREQUENCY RESPONSE JPL 902.35-01

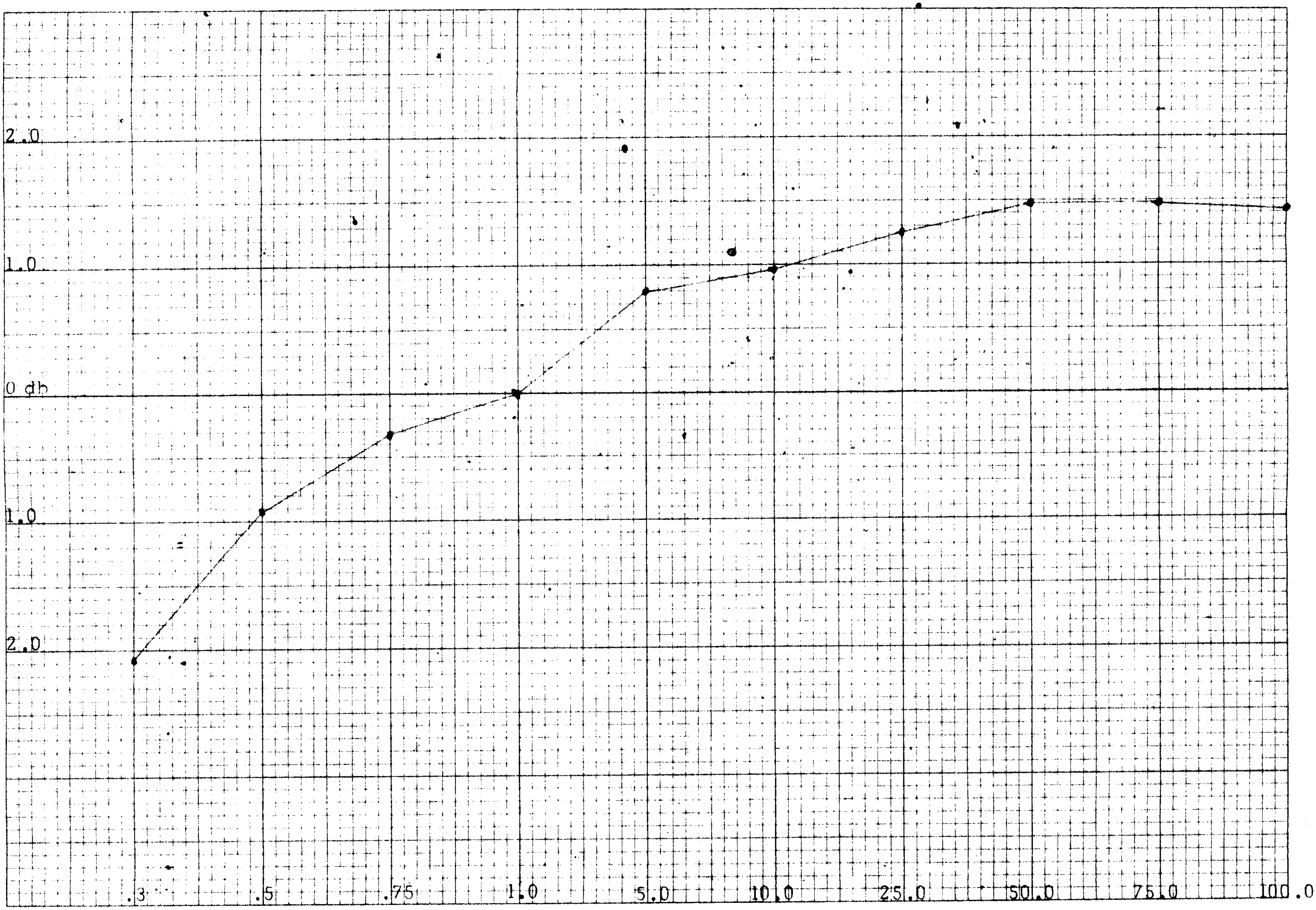
TRIAD SP66 FREQUENCY RESPONSE JPL 902.35-01



NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

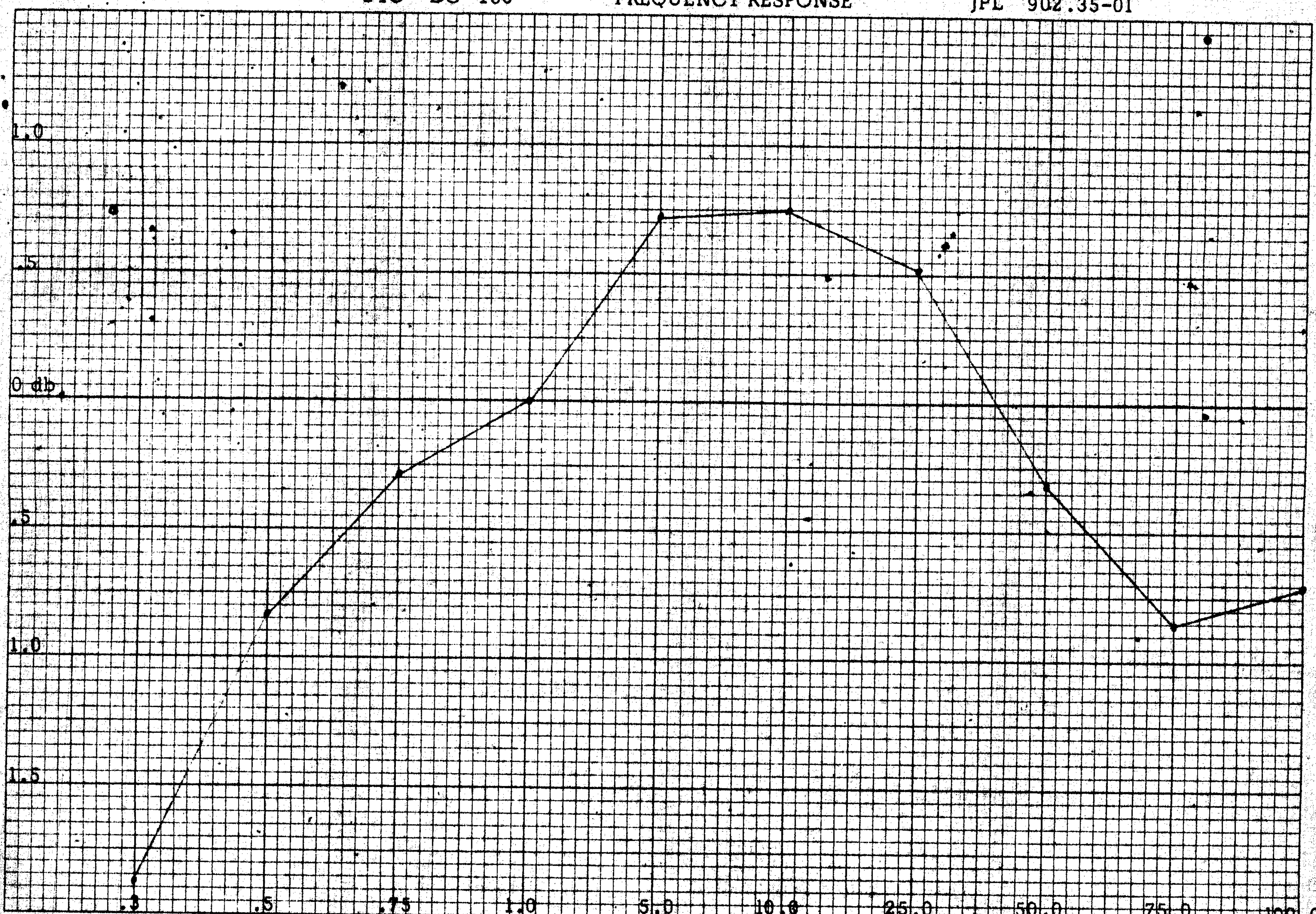
UTC DO T10 FREQUENCY RESPONSE JPL 902.35-01



NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

UTC DO T36 FREQUENCY RESPONSE JPL 902.35-01



4.2.3 Parametric Failures by Group and Vendor as computed from the Computed Statistics Sheets. (NOTE: All parametric failures discussed in this section are with respect to primary inductance, Para. Code 03 and were below the minimum acceptable value.)

4.2.3.1 <u>Group I</u>

A. Microtran PM7-M
   1. All units failed throughout entire test cycle.

B. Microtran PM17-M
   1. All units failed throughout entire test cycle.

C. Triad SP-5
   1. Two units (66.7%) failed after the temperature cycling test and after all subsequent tests.

D. Triad SP-66
   1. All units failed throughout entire test cycle.

4.2.3.2 <u>Group II</u>

A. Microtran PM7-M
   1. One unit (11.1%) failed on initial measurement. Serial No. 005 read 25.38 HY.
   2. Three units (33.3%) failed after shock and vibration test.
   3. One unit (12.2%) failed moisture resistance test. Serial No. 005 read 24.77 HY.
   4. Two units (25%) failed after temperature cycling test.
   5. Six units (75%) failed 168 hour life test.
   6. Seven units (87.5%) failed after 500 and 1000 hour life tests.
   7. Five units (62.5%) failed after 1500 hour life test.
   8. Seven units (87.5%) failed 2000 hour life test.

B. Microtran PM17-M
   1. All units failed throughout entire test cycle.

C. Triad SP-5
   1. Four units (44.4%) failed initial electrical.
   2. Five units (55.6%) failed after shock.
   3. Four units (44.4%) failed after vibration and moisture resistance.

4. Five units (55.6%) failed temperature cycle.

5. Six units (66.7%) failed throughout remainder of test cycle.

D. Triad SP-66

1. All units failed throughout entire test cycle.

4.2.3.3 Group III

A. Microtran PM7-M

1. Two units (66.7%) failed initial electrical.

B. Microtran PM17-M

1. All units failed initial electrical.

C. Triad SP-5

1. One unit (33.3%) failed throughout entire high temperature life test cycle.

D. Triad SP-66

1. All units failed throughout entire test cycle.

4.2.3.4 Summary Chart of Parametric Failures

Number of Parametric Failures
(Max Number/A Group)

		Group I				Group II				Group III			
		PRI DCR	SEC DCR	PRI IND	T.R.	PRI DCR	SEC DCR	PRI IND	T.R.	PRI DCR	SEC DCR	PRI IND	T.R.
Microtran	PM7-M	0	0	3	0	0	0	7	0	0	0	2	0
Microtran	PM17-M	0	0	2	0	0	0	9	0	0	0	3	0
Triad	SP-5	0	0	2	0	0	0	6	0	0	0	1	0
Triad	SP-66	0	0	3	0	0	0	9	0	0	0	3	0
UTC	DO-T10	0	0	0	0	0	0	0	0	0	0	0	0
UTC	DO-T36	0	0	0	0	0	0	0	0	0	0	0	0

4.3 Description of Parameter Changes with Environmental and Life Tests

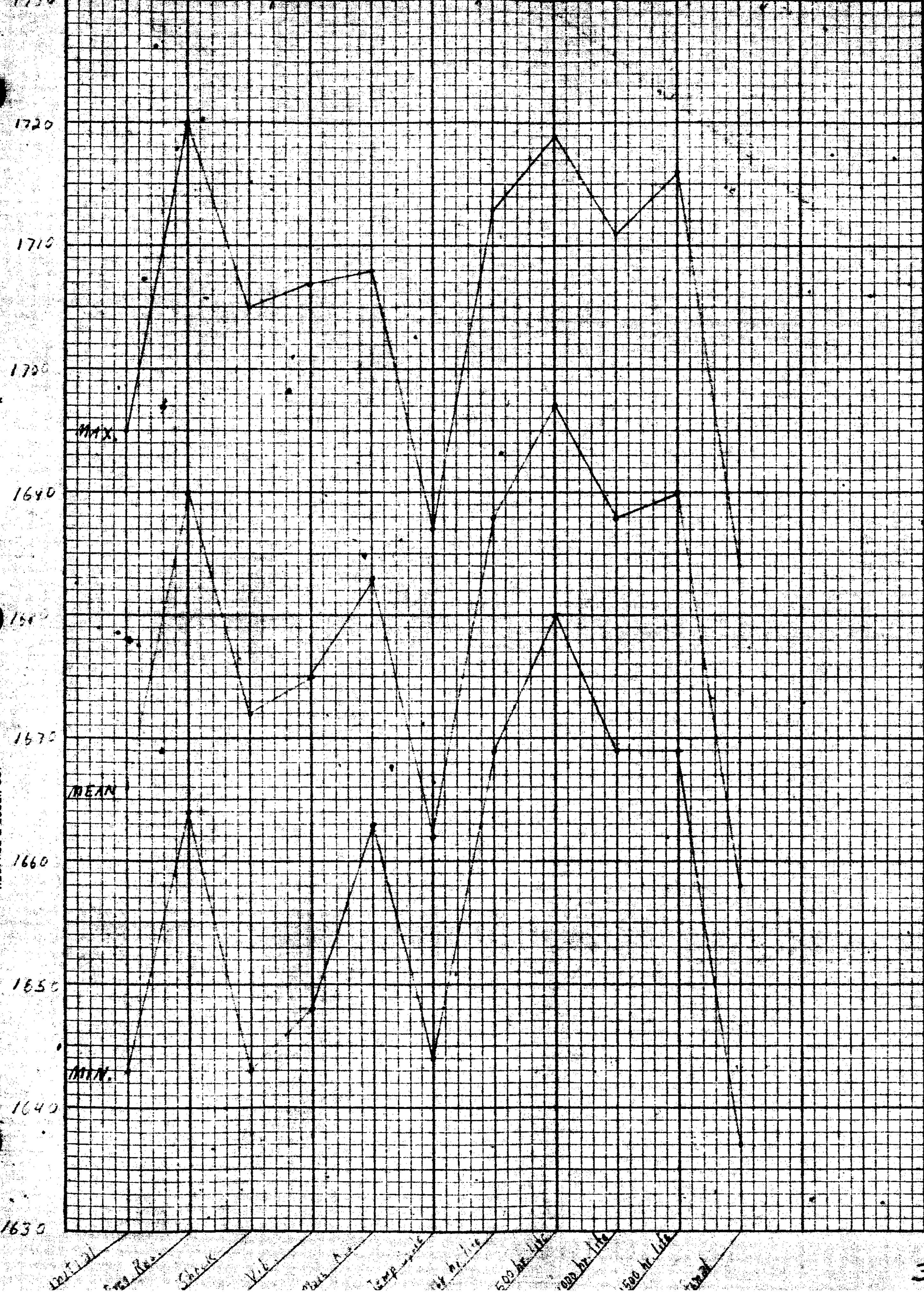
Parameter changes with environmental are shown in two ways for ease of observation and analysis; they are:

1. Parameter variations of each group, as a whole, with no attempt to mode to separate part type.
2. Parameter variations of each type within each group.

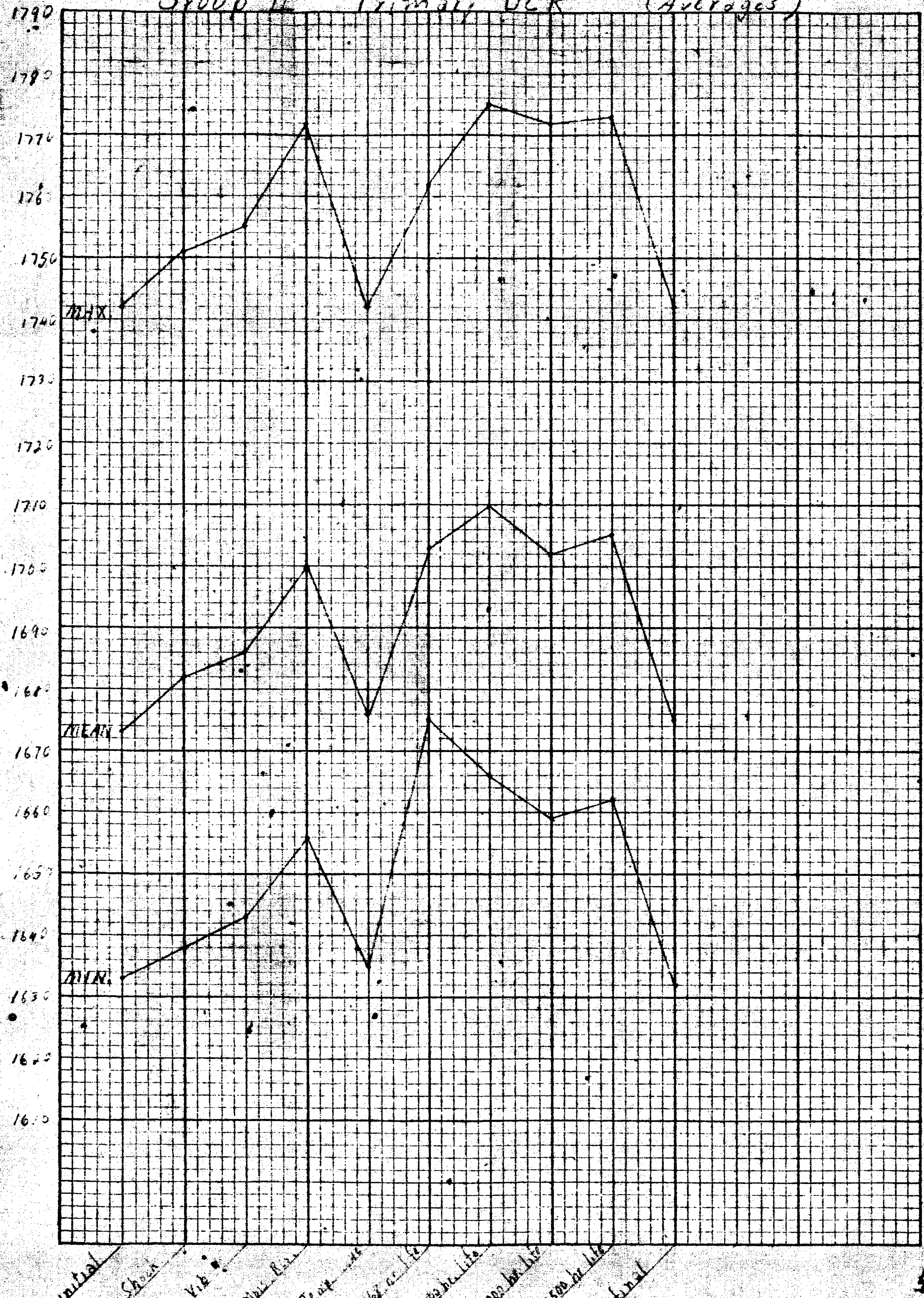
4.3.1 Parameter Changes of a Group

Taking each group as a whole, the average values of min, mean, and max for Primary DCR, Secondary DCR, and Primary Inductance were computed from the Computed Statistics Sheets for each measurement point. This information is presented graphically in order to facilitate an analysis of parameter variations induced by the particular type of test cycle.

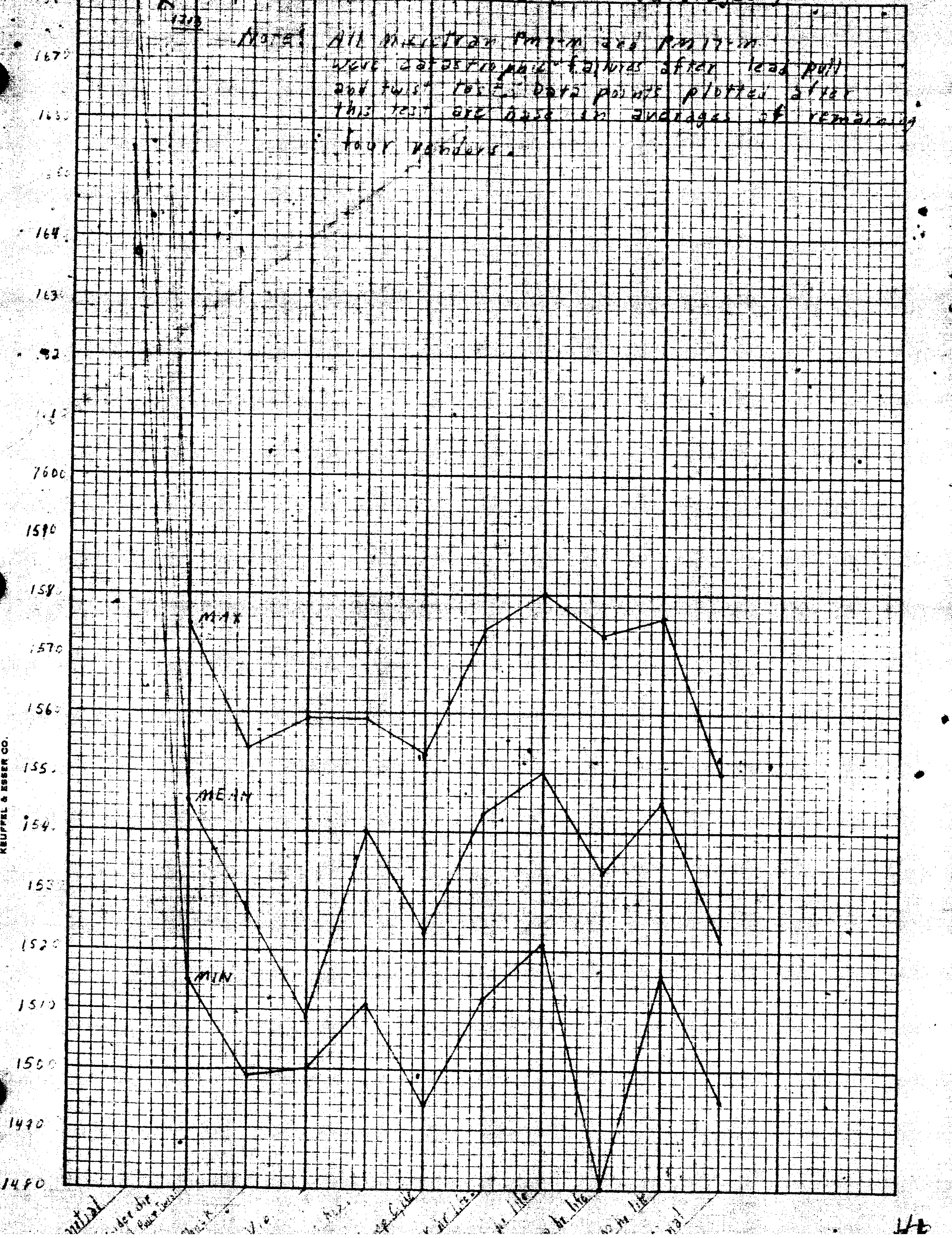
Group I Primary DCR (Averages)



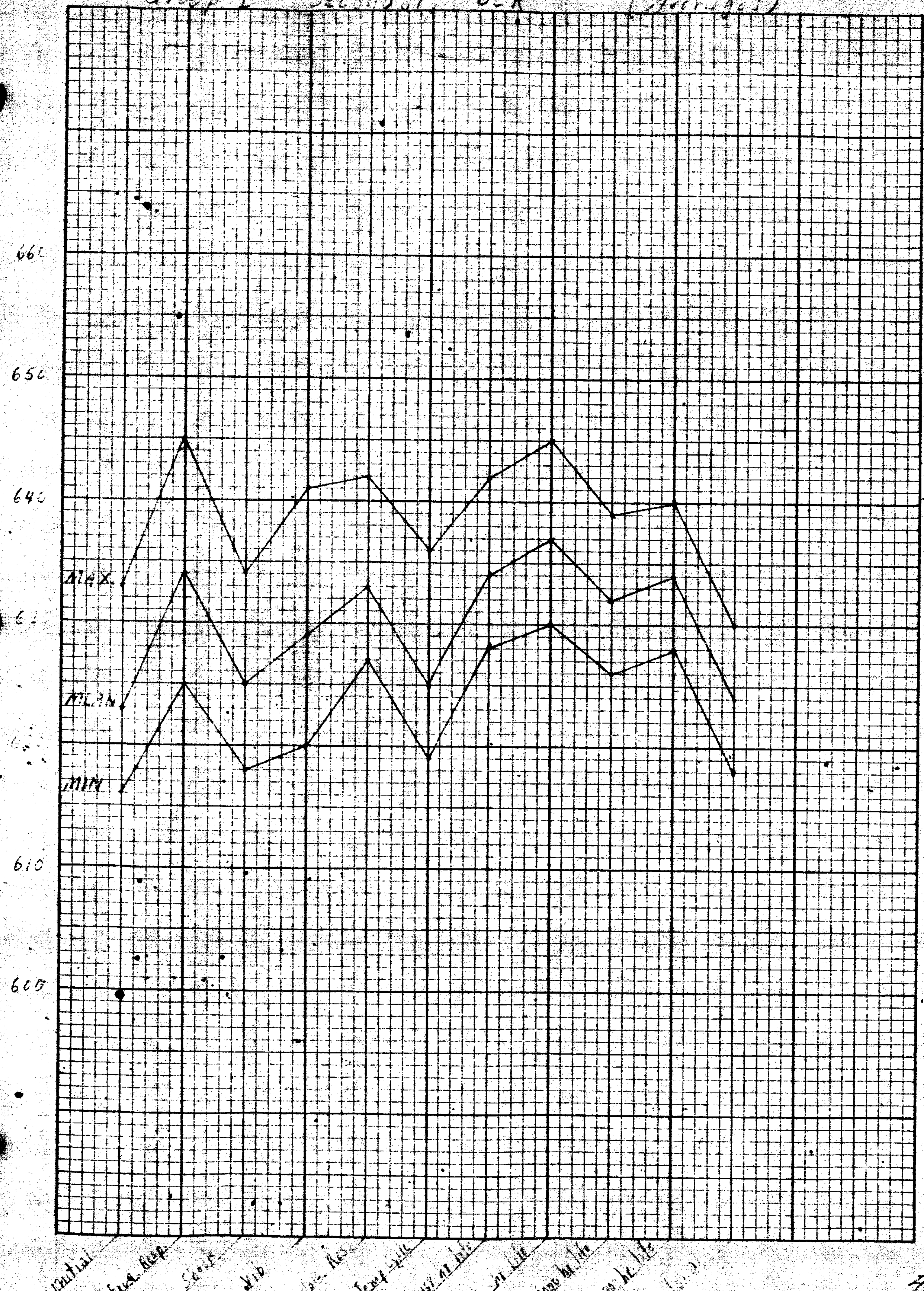
Group II Primary DCR (Averages)



Group III Primary DCR (Averages)

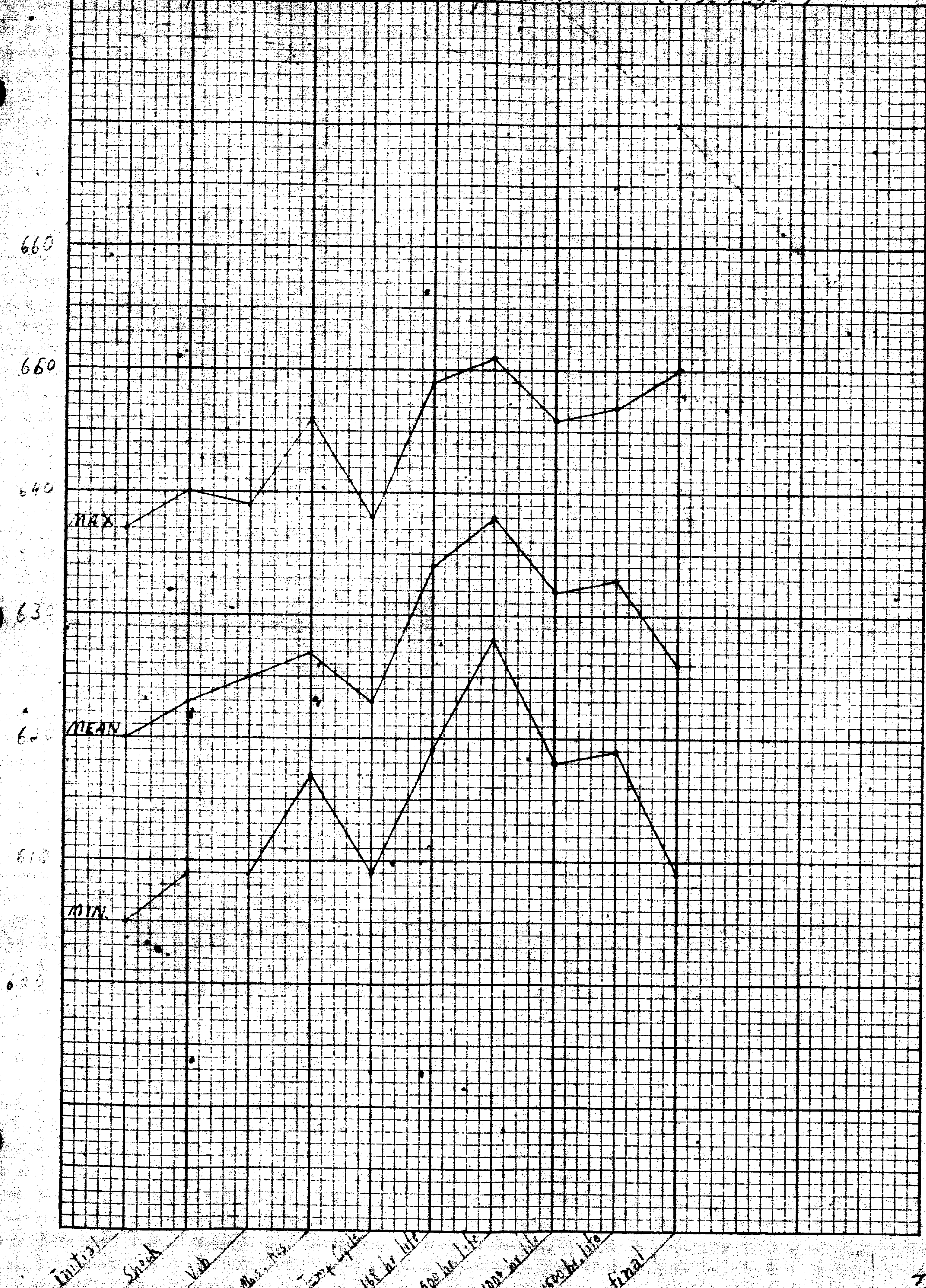


Group I Secondary DCR (Averages)

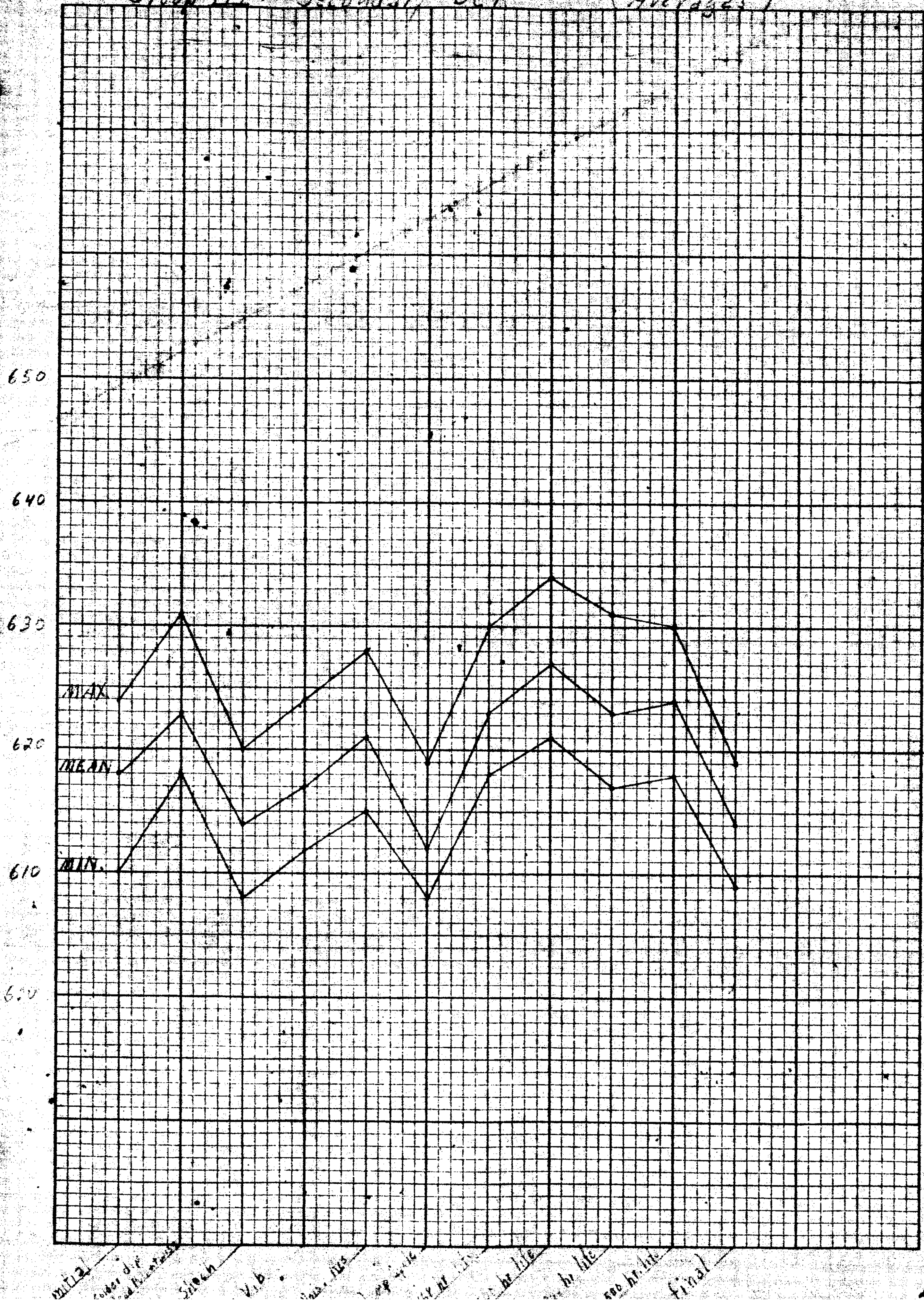


KE 10 X 10 TO THE INCH 46 0782
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

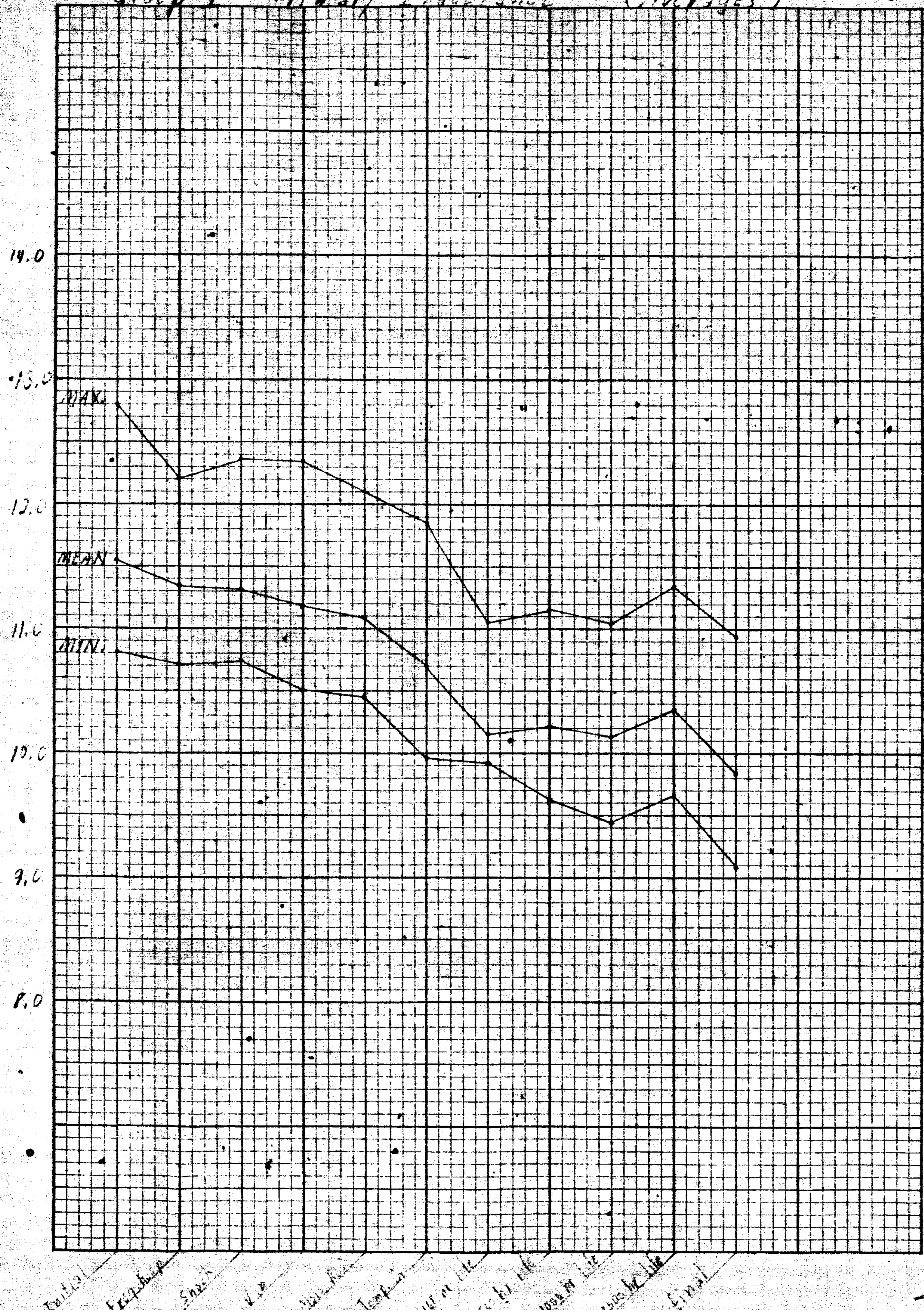
Group II Secondary DCR (Averages)



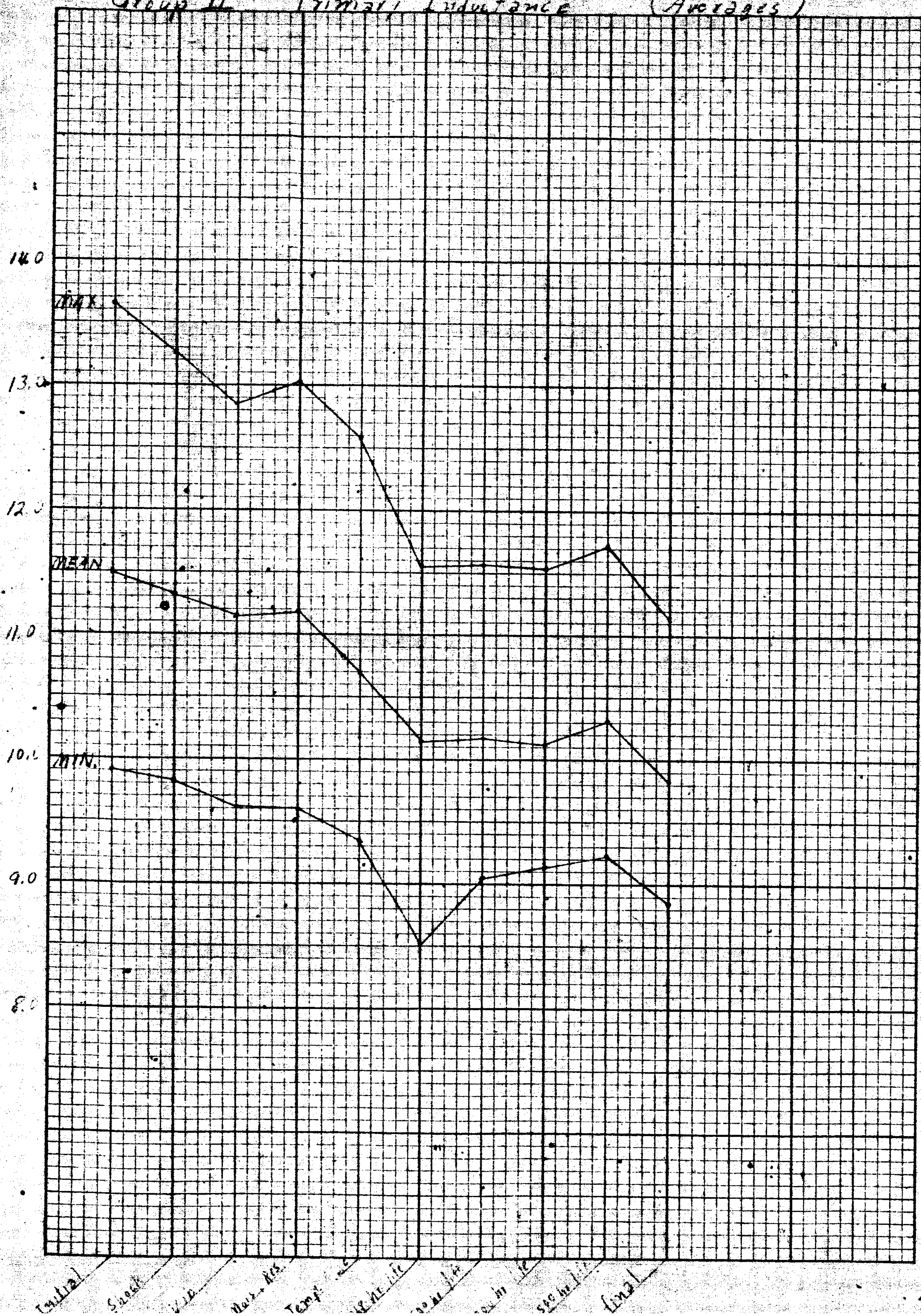
Group III. Secondary DCR (Averages)



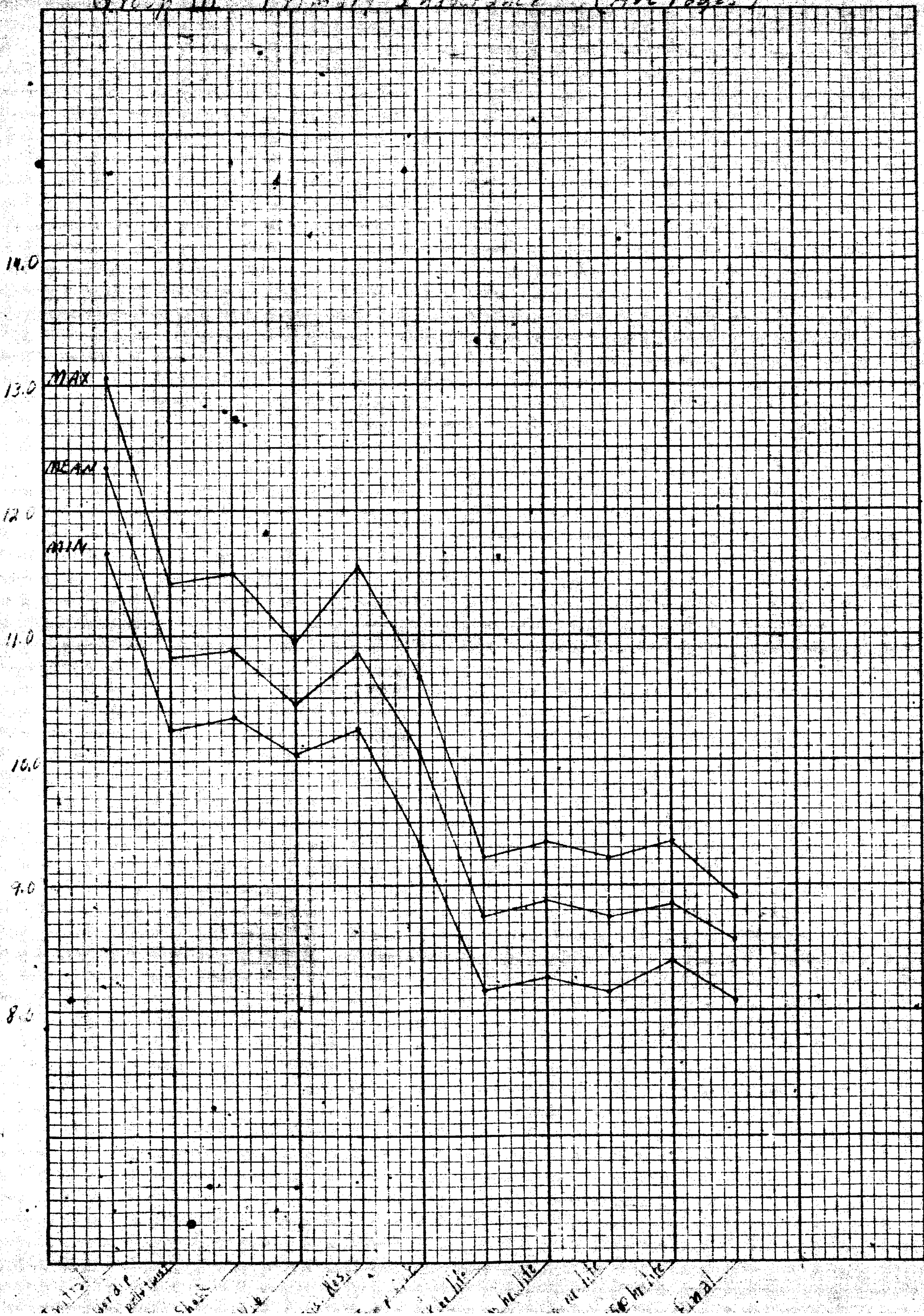
Group I Primary Inductance (Averages)



Group II Primary Inductance (Averages)



Group III Primary Inductance (Averages)

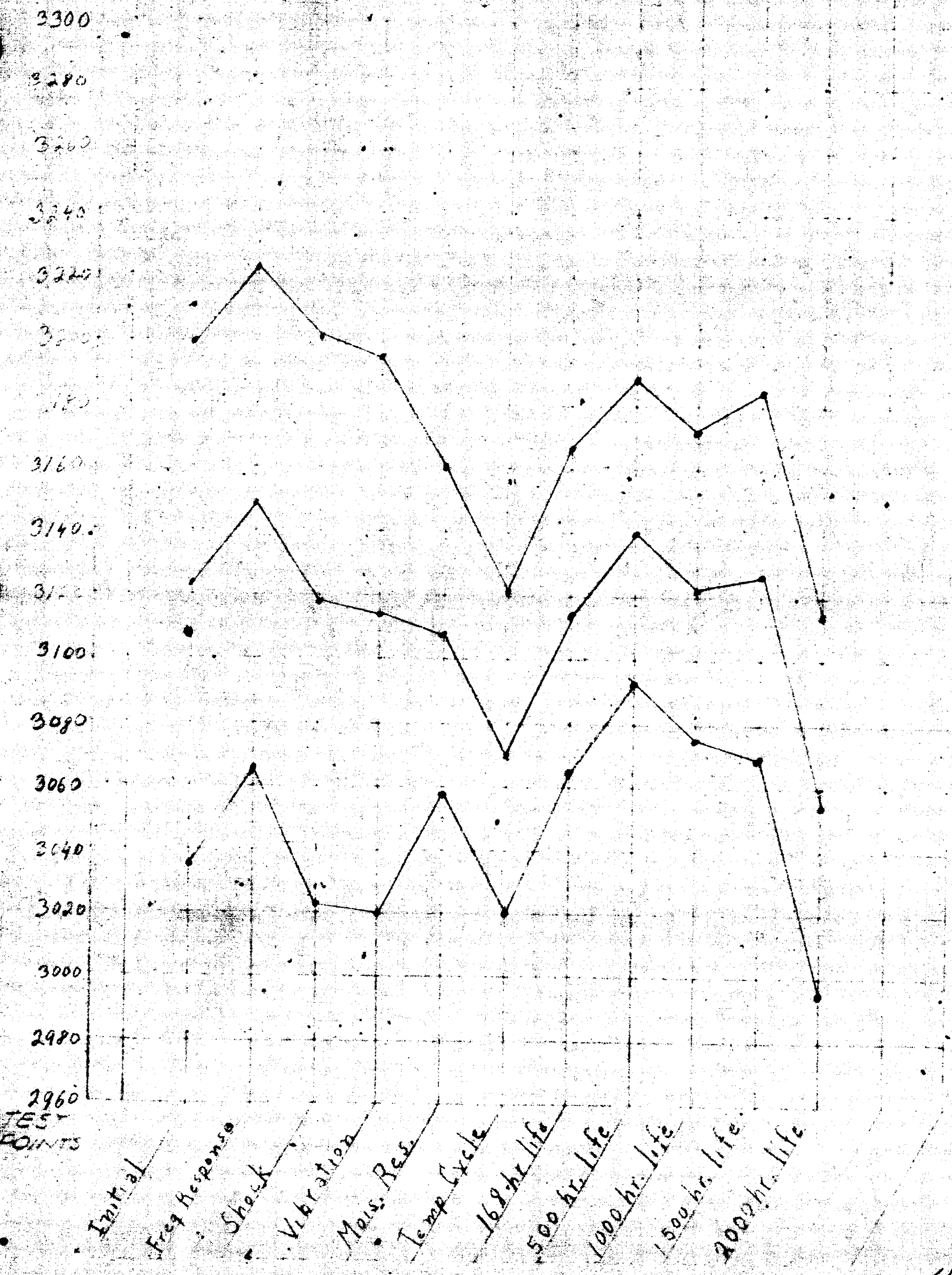


4.3.2 Parameter Changes of a Type within a Group

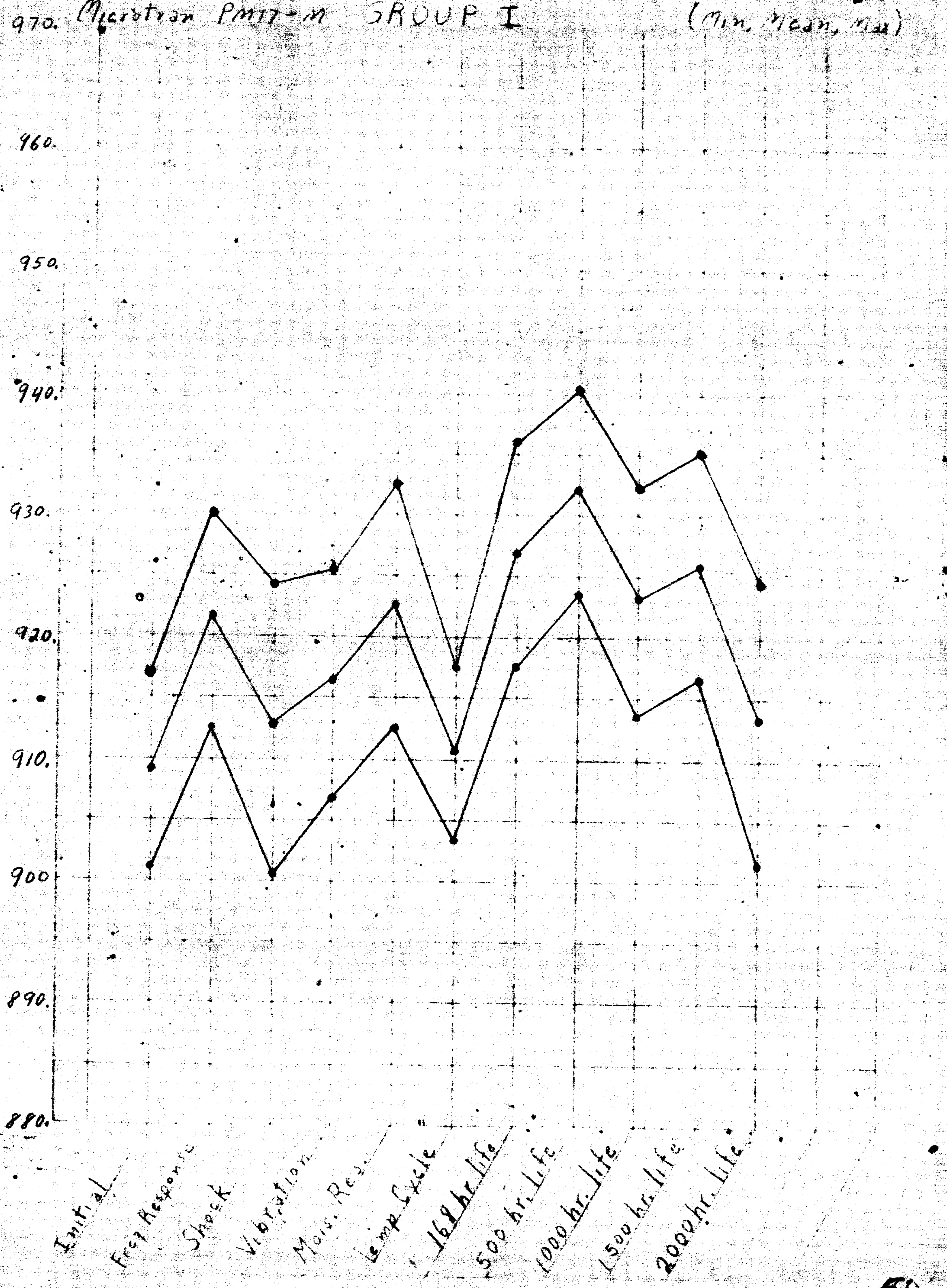
The min, mean, and max values, by group, for each measurement point are shown in the Computed Statistics Sheets. From these figures the following charts were made which graphically show parameter changes for each component.type within a group.

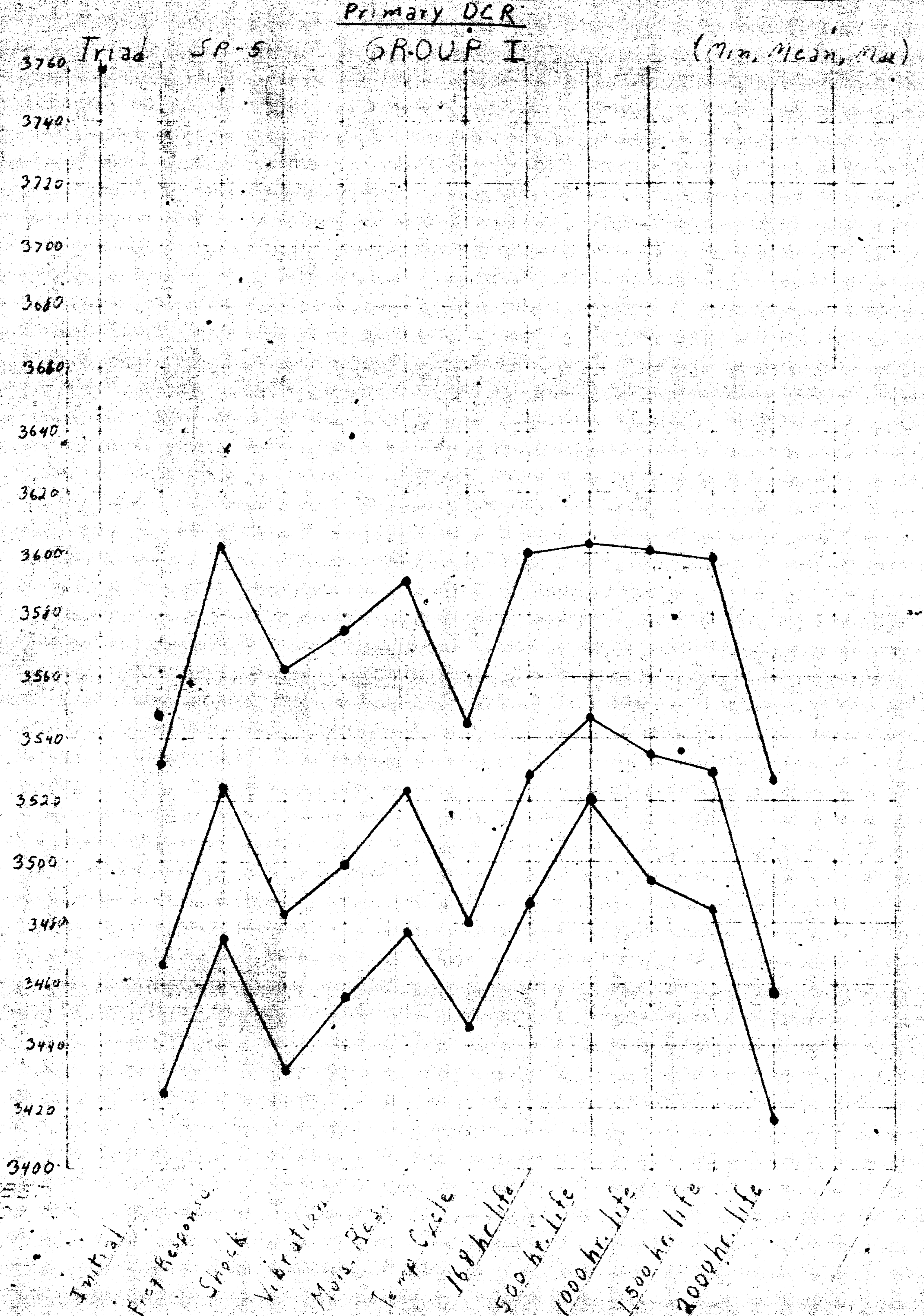
Primary DCR

Microtran PM2-M GROUP I (Min, Mean, Max)



Primary DCR

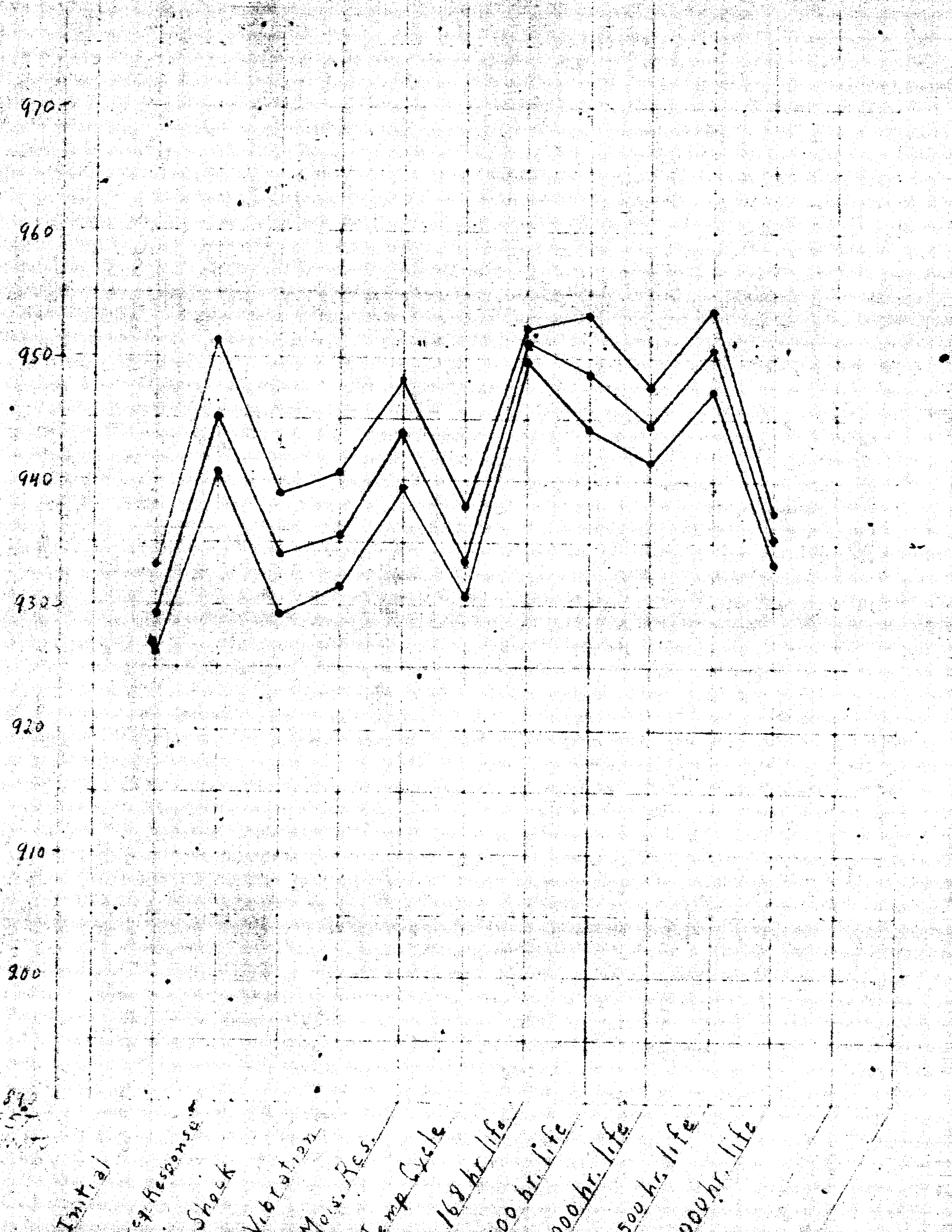

Microtron PM17-M GROUP I
(Min. Mean, Max)
970.
960.
950.
940.
930.
920.
910.
900
890.
880.
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr. life
500 hr. Life
1000 hr. life
1500 hr. life
2000 hr. Life



Primary DCR
Triad SP-5
GROUP I
(Min. Mean, Max)
3760
3740
3720
3700
3680
3660
3640
3620
3600
3580
3560
3540
3520
3500
3480
3460
3440
3420
3400
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

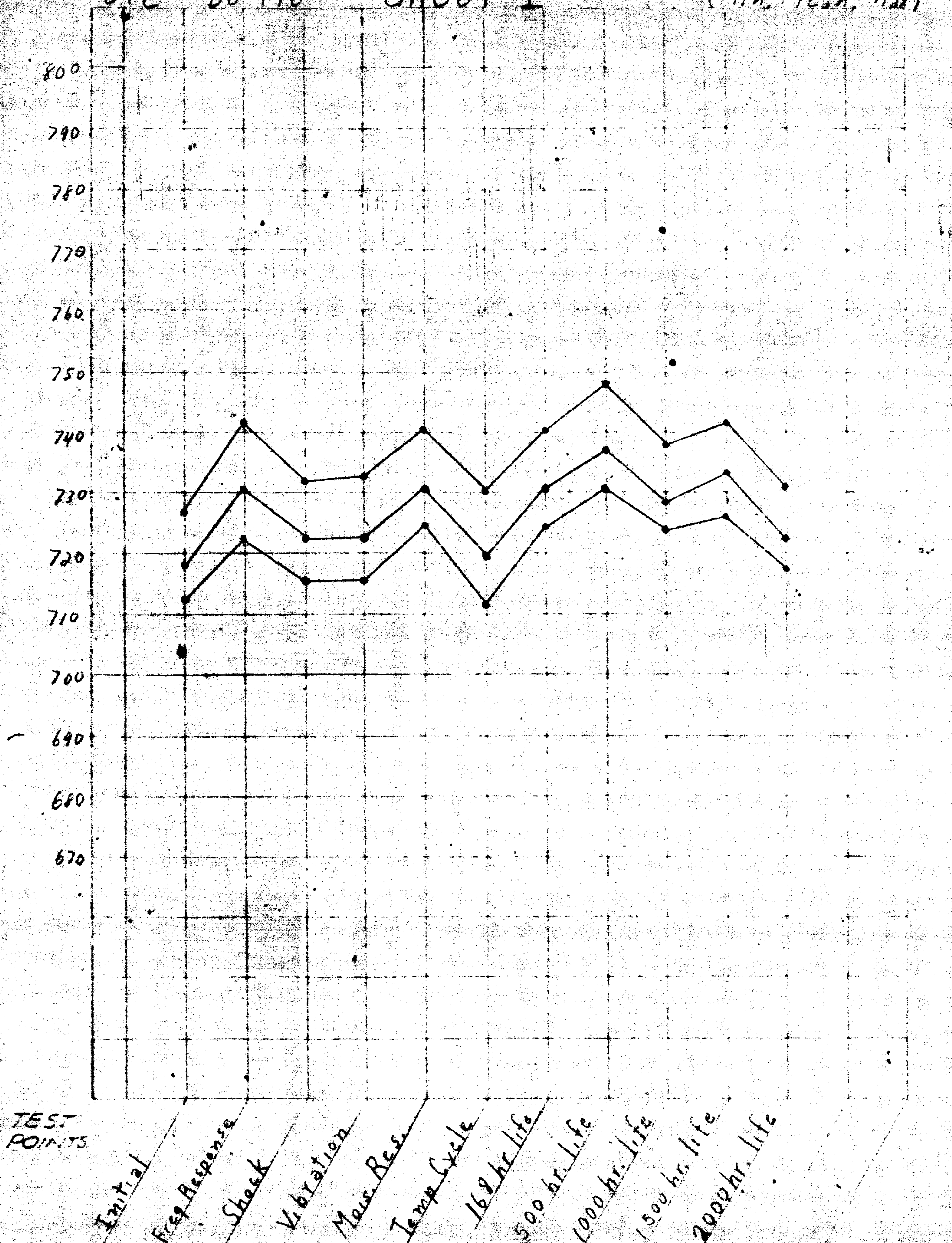
Primary DCR

Triad SP-66 GROUP I (Min, Mean, Max)

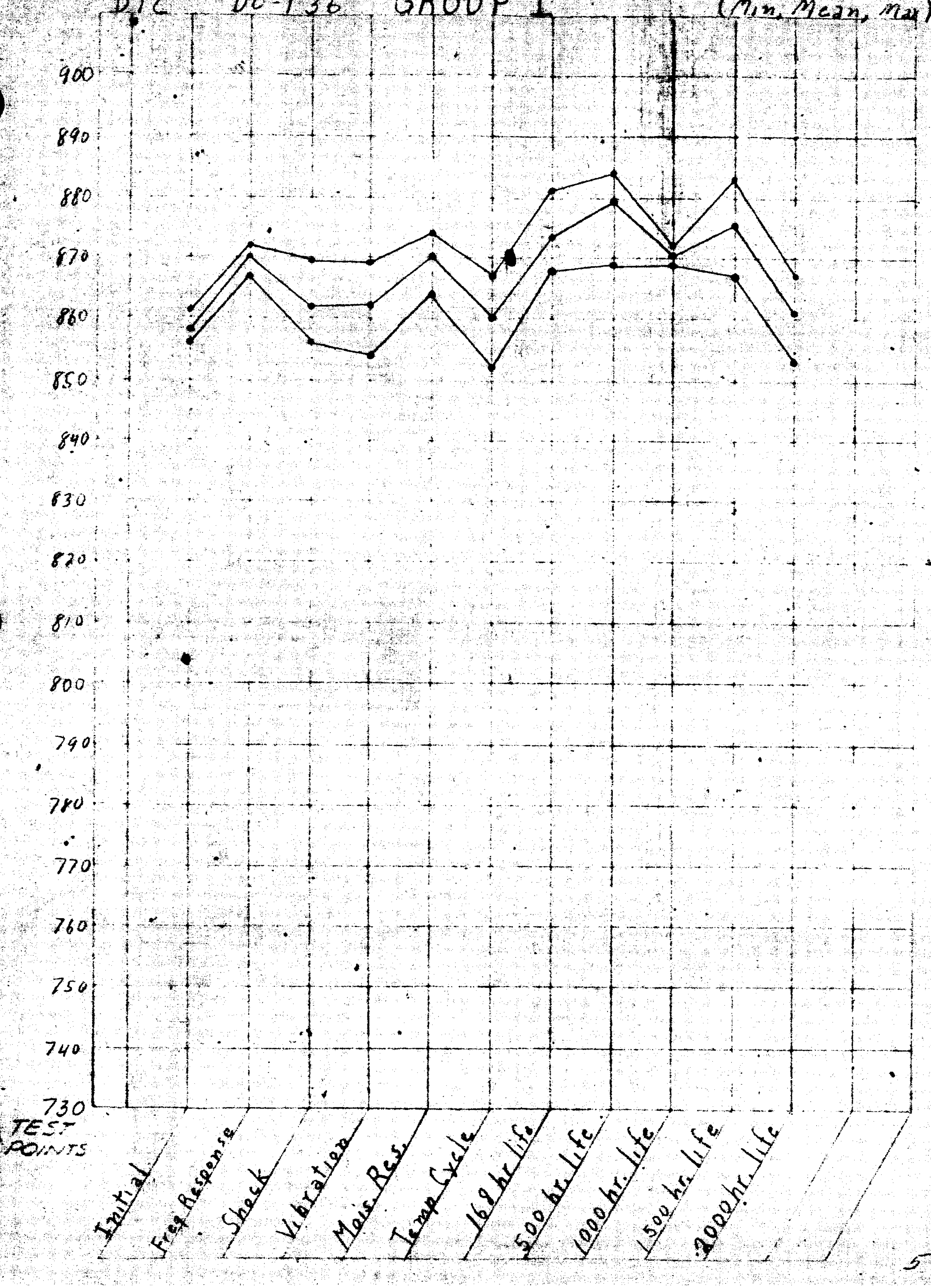


Primary DCR

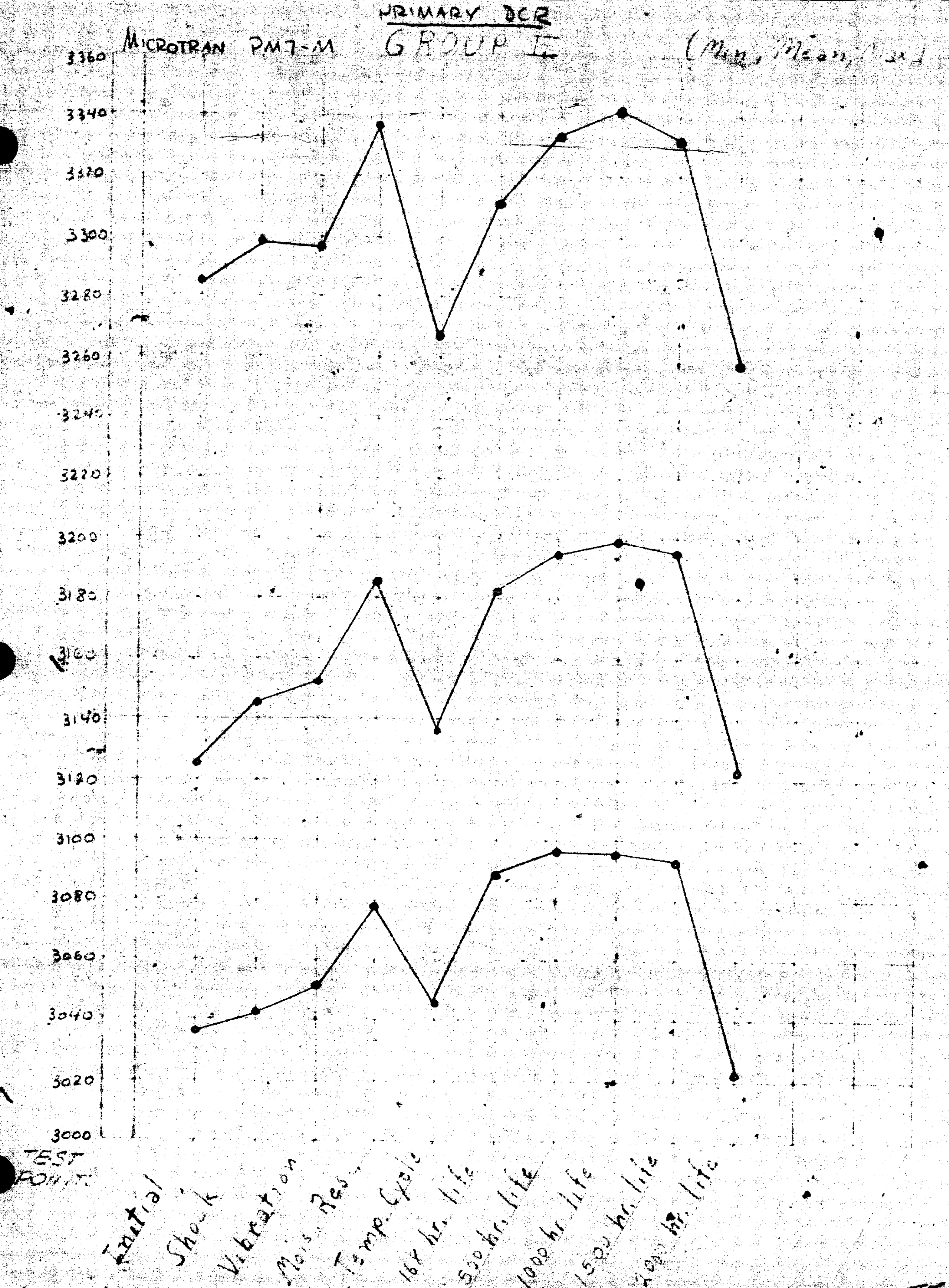
UTC DO-T10 GROUP I (Min, Mean, Max)



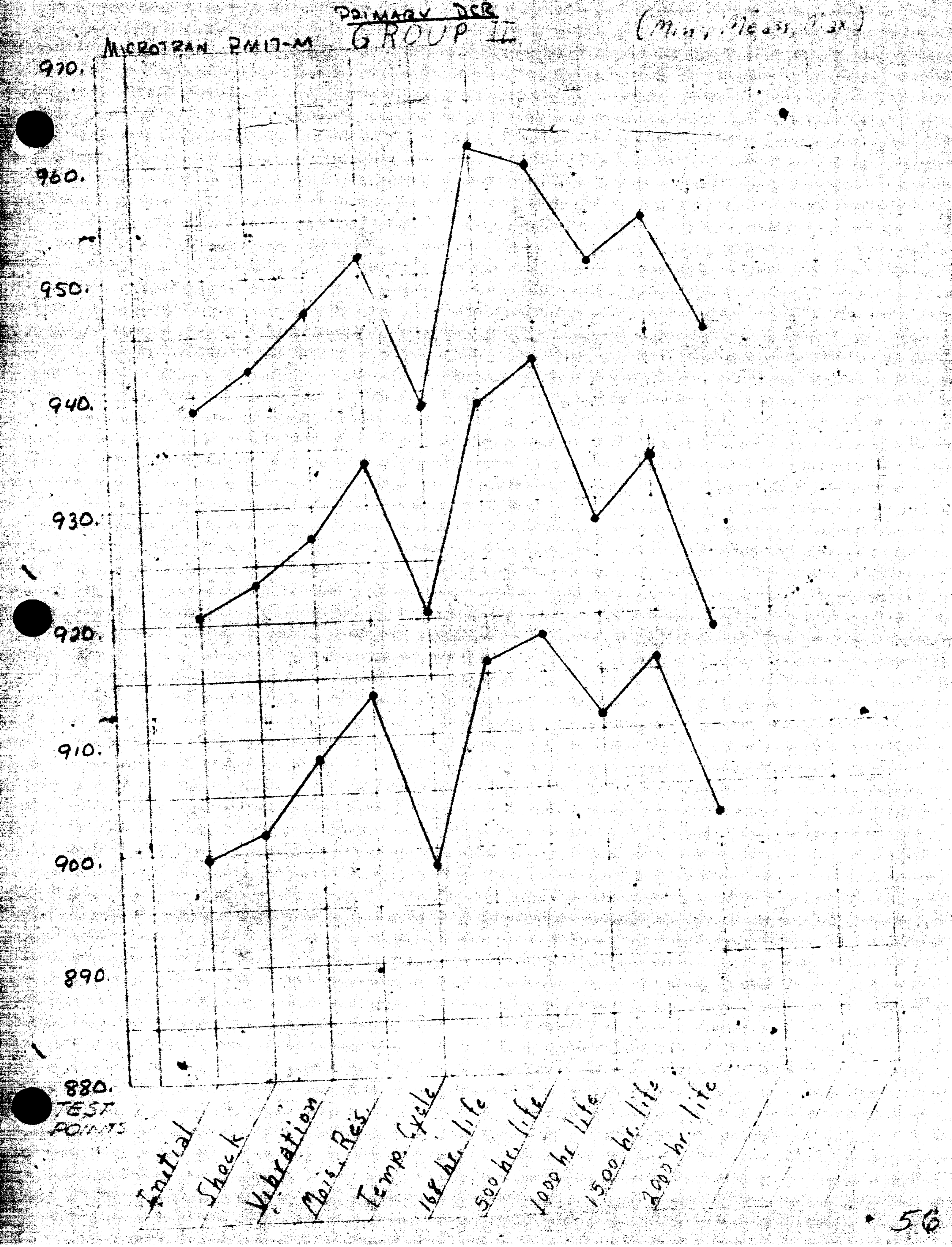
Primary DCR



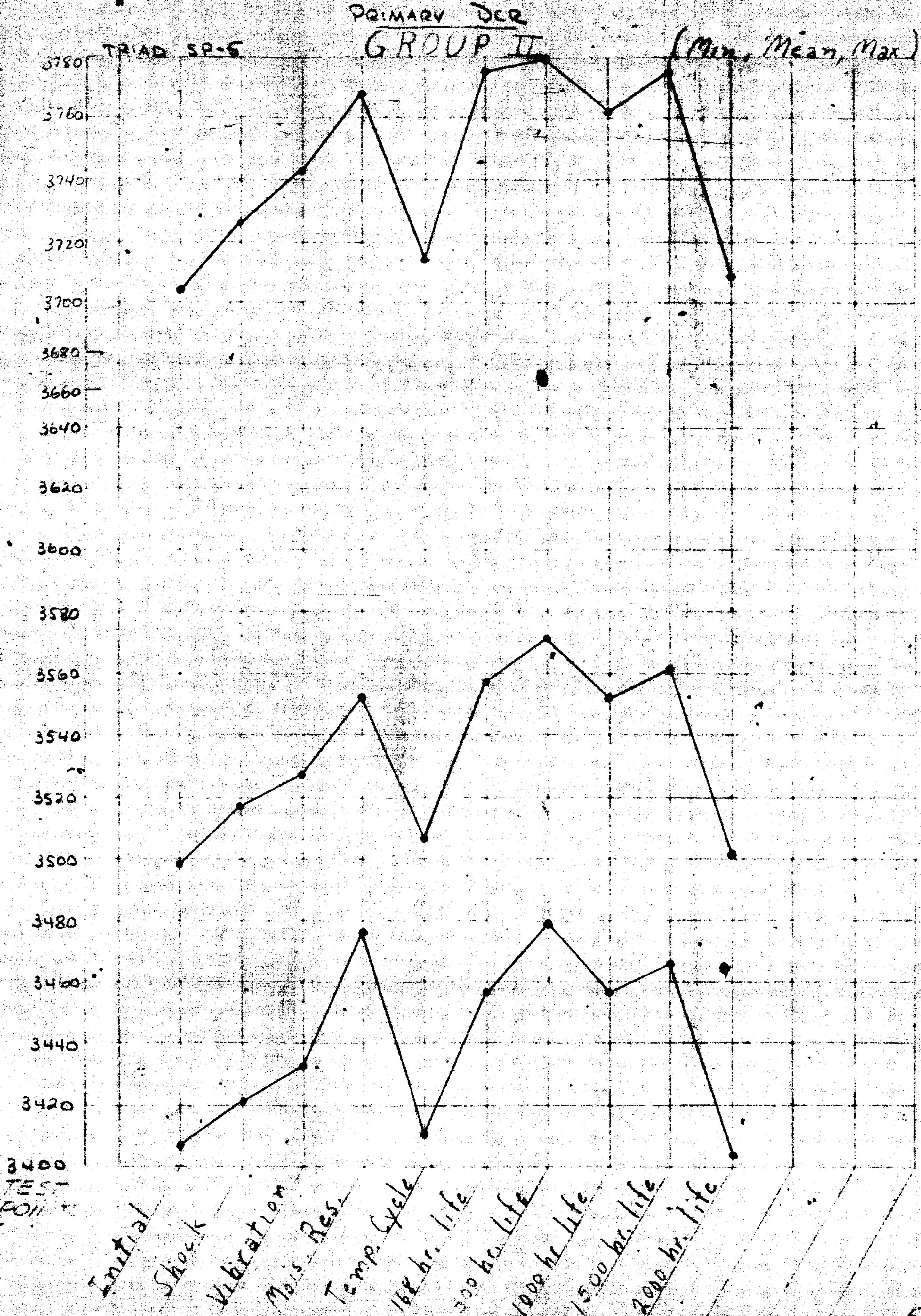
UTC DC-T36 GROUP I (Min, Mean, Max)
900
890
880
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
TEST POINTS
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life



PRIMARY DCR
MICROTRAN PM7-M GROUP II
(Min, Mean, Max)
3360
3340
3320
3300
3280
3260
3240
3220
3200
3180
3160
3140
3120
3100
3080
3060
3040
3020
3000
TEST POINT
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life



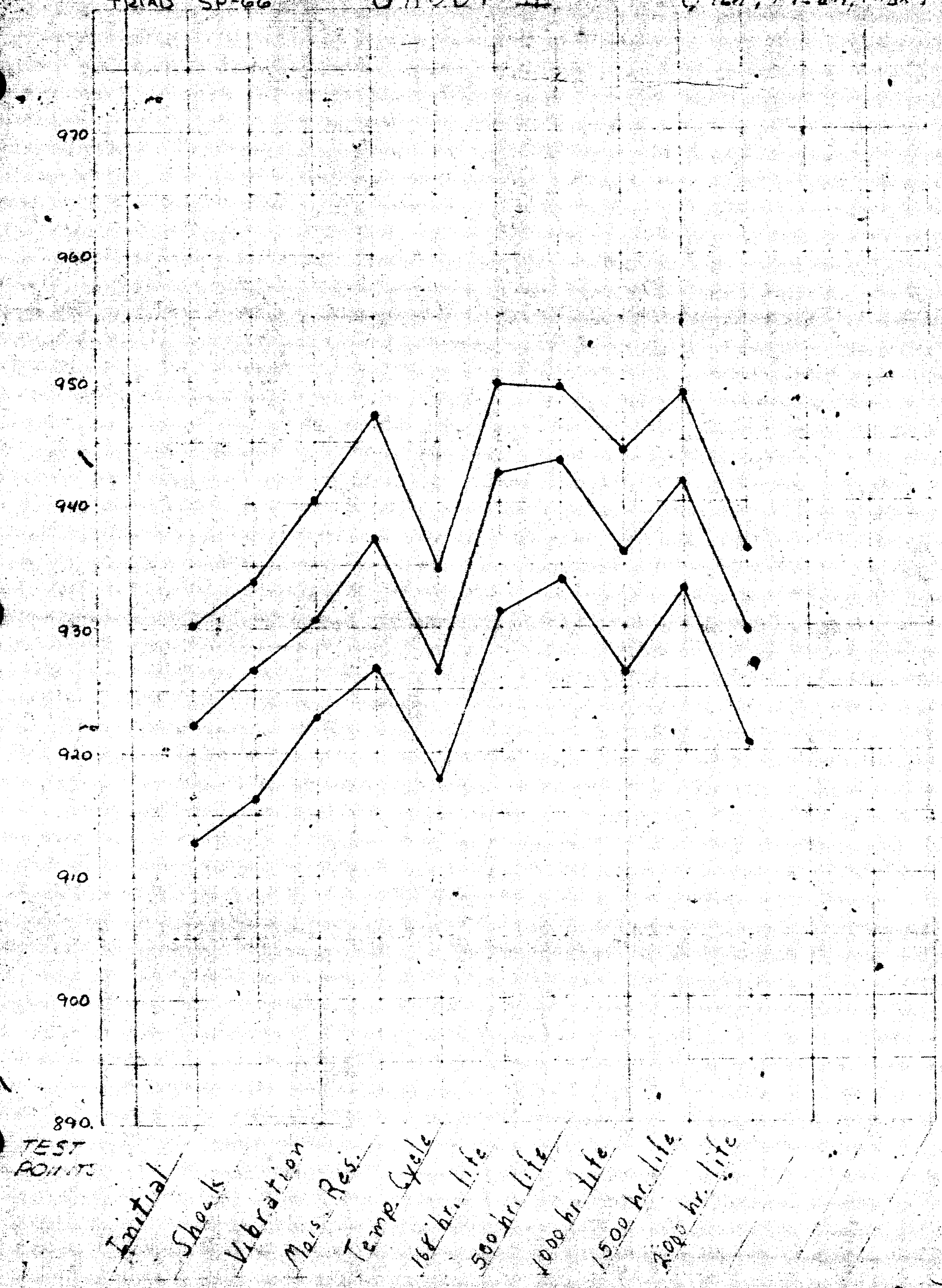
PRIMARY DCR
MICROTRAN PM17-M
GROUP II
(Min, Mean, Max)
970.
960.
950.
940.
930.
920.
910.
900.
890.
880.
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

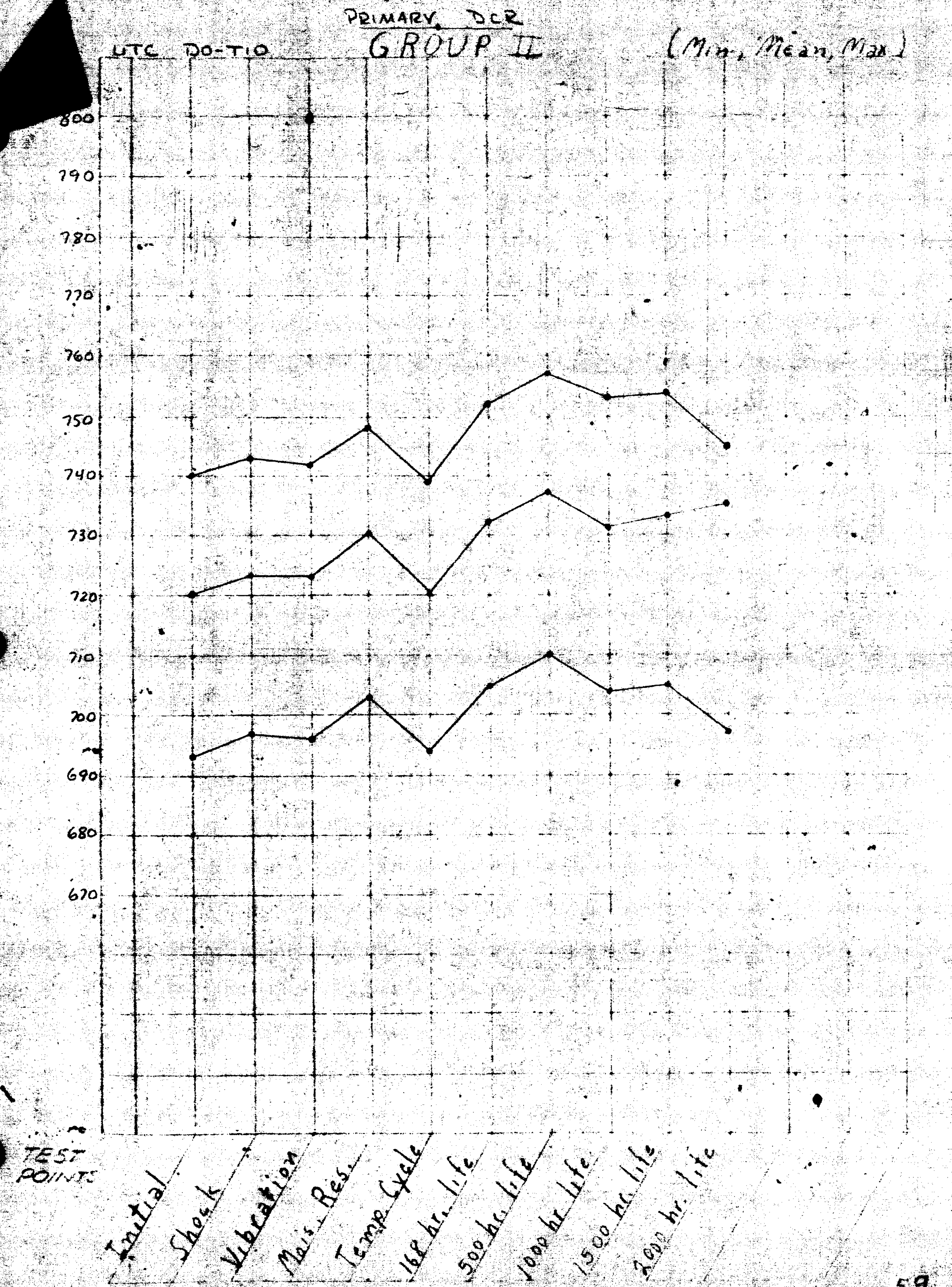

PRIMARY DCR
TRIAD SP-5
GROUP II
(Min, Mean, Max)
3780
3760
3740
3720
3700
3680
3660
3640
3620
3600
3580
3560
3540
3520
3500
3480
3460
3440
3420
3400
TEST
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr life
1500 hr. life
2000 hr. life

PRIMARY DCR

GROUP II

TRIAD SP-66 (Min, Mean, Max)





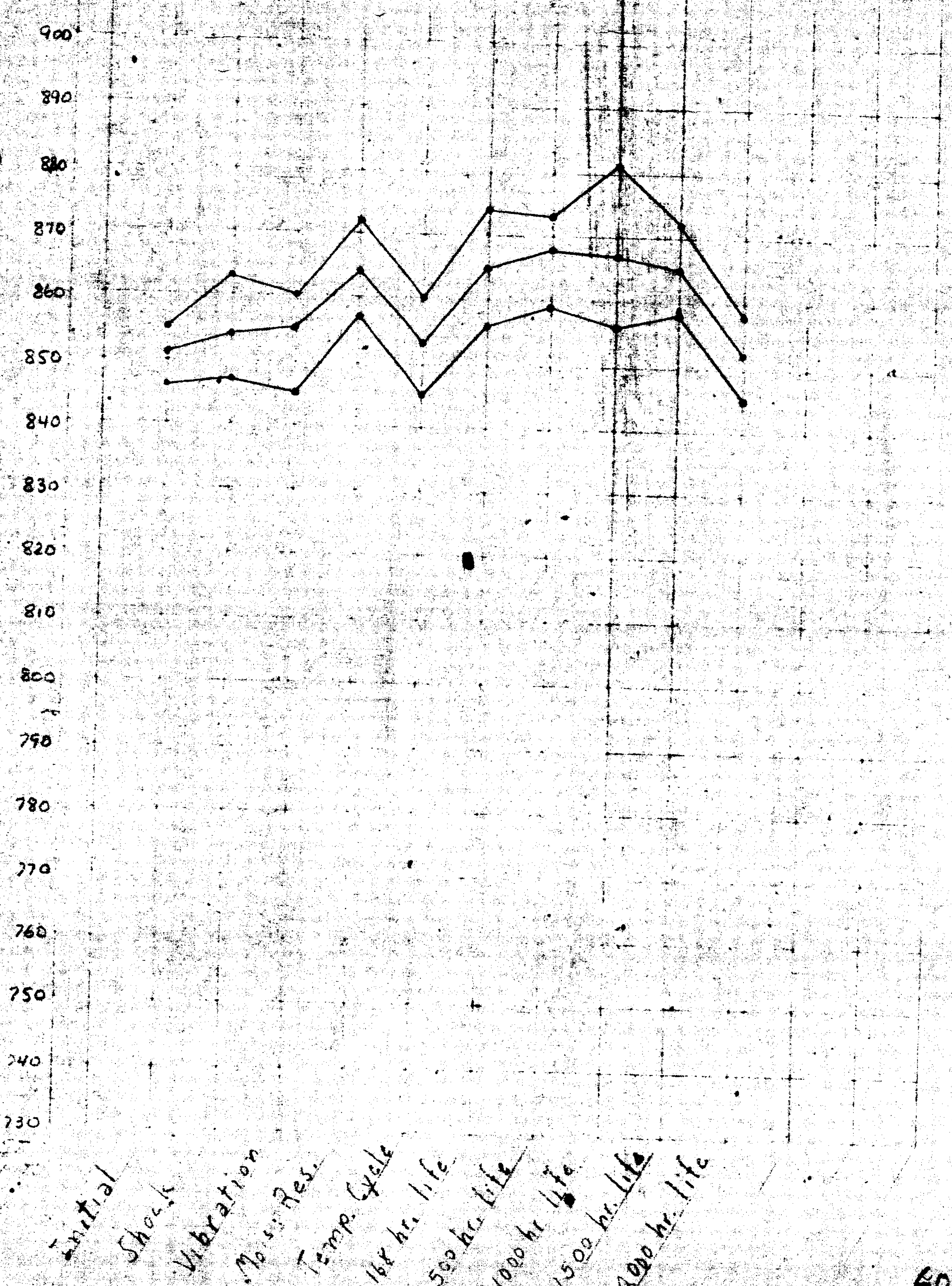
PRIMARY DCR
UTC DO-T10
GROUP II
(Min., Mean, Max)
800
790
780
770
760
750
740
730
720
710
700
690
680
670
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

UTC DO-T36

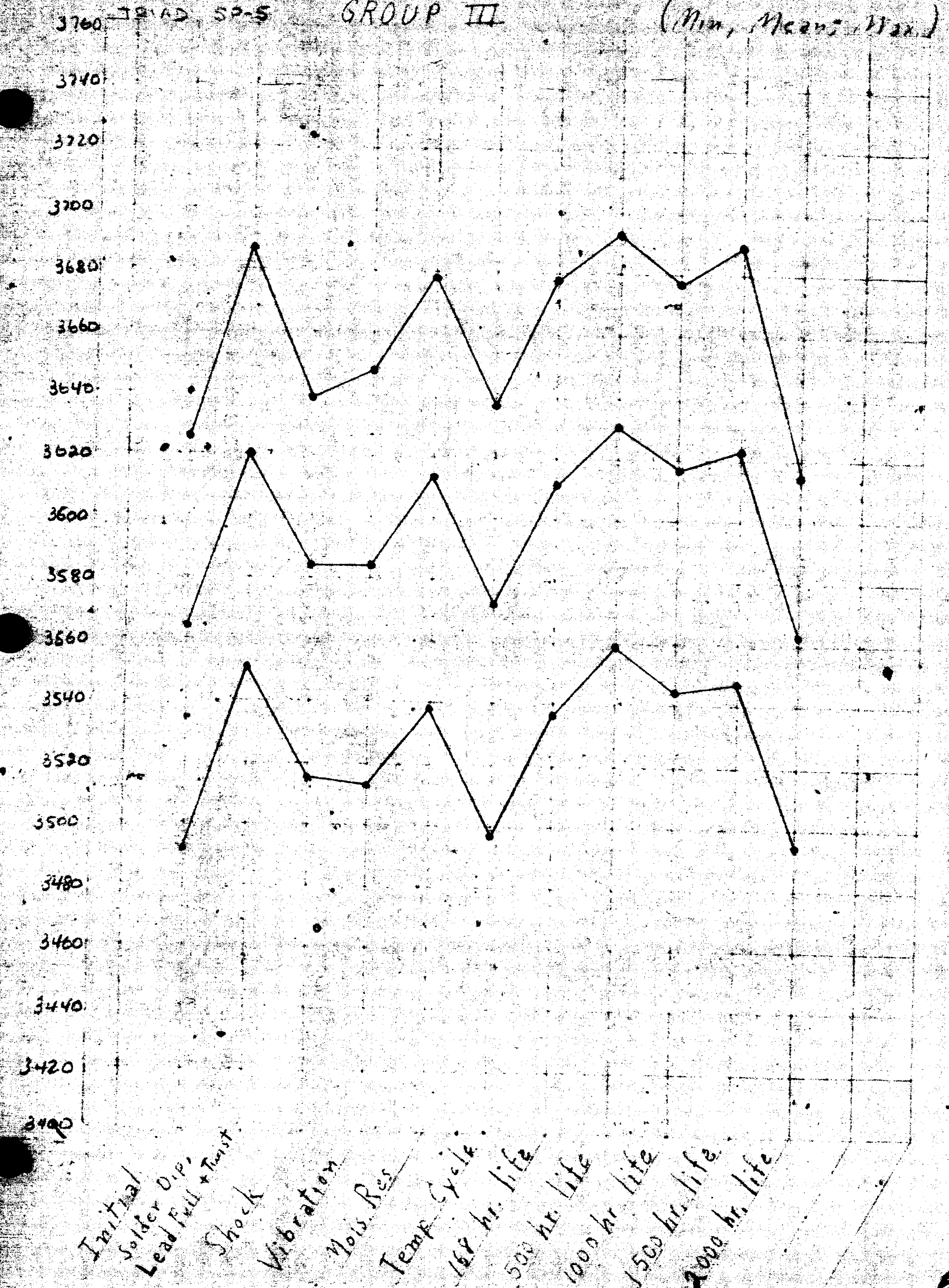
PRIMARY DCR

GROUP II

(Min, Mean, Max)

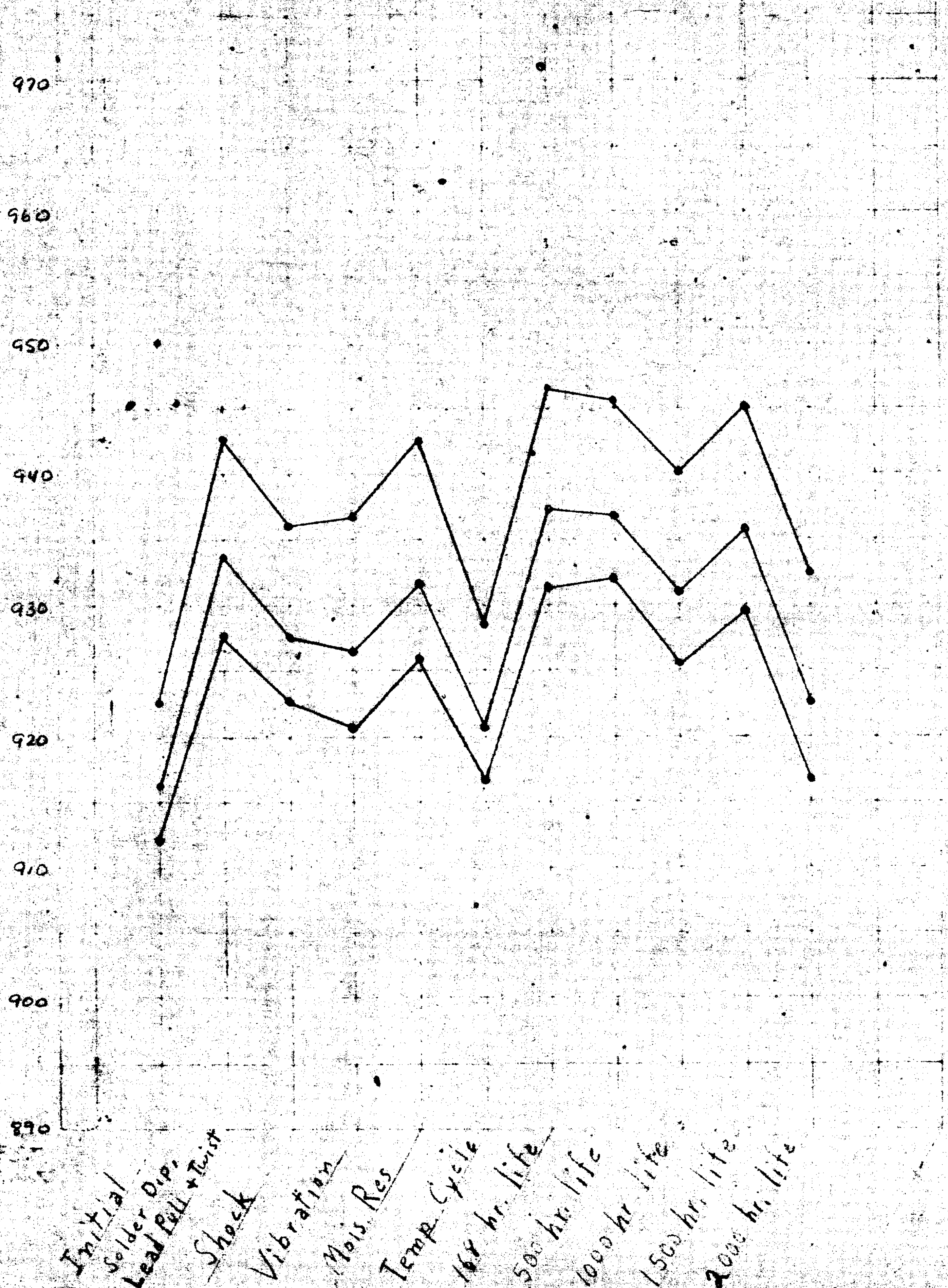


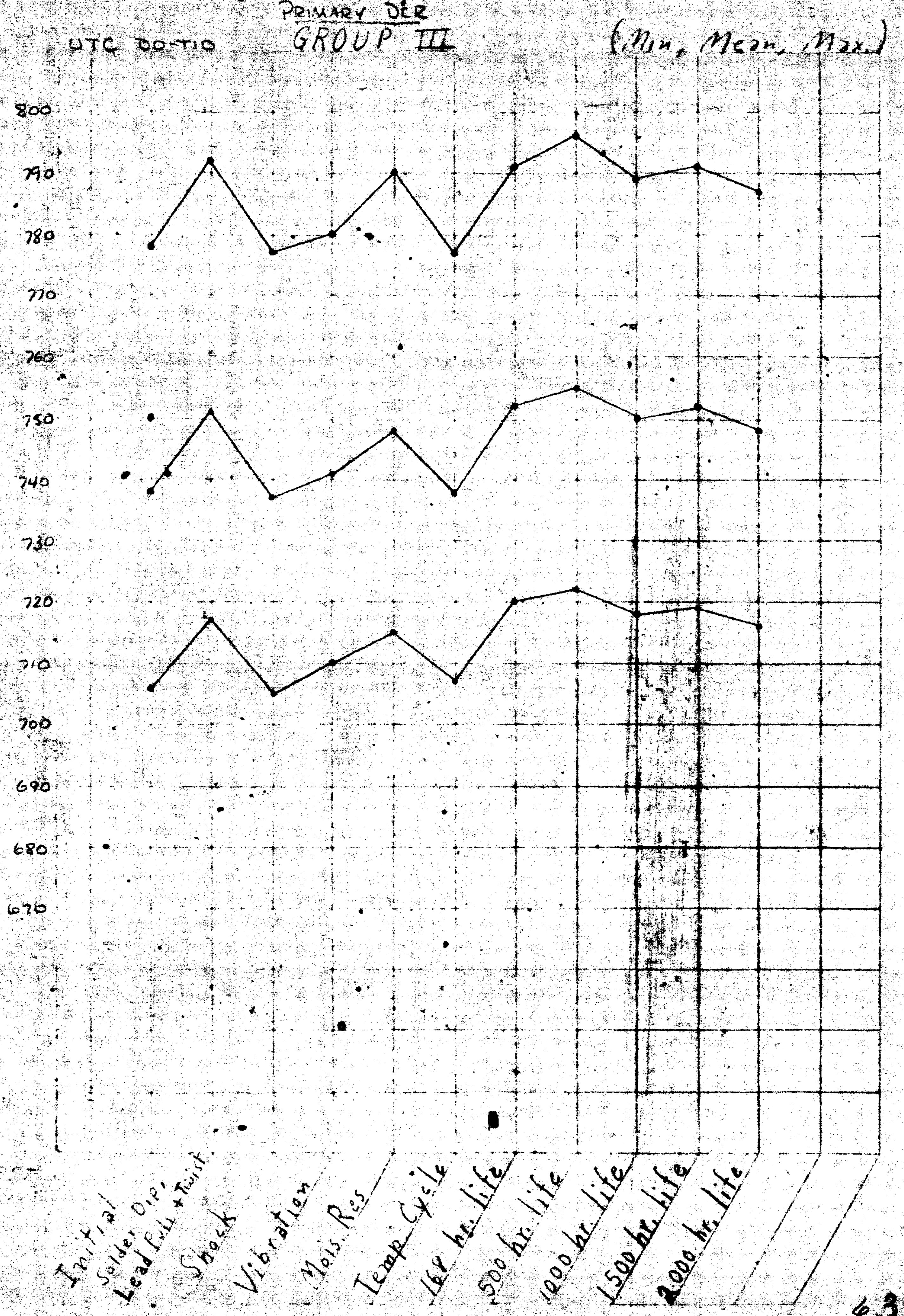
PRIMARY DCR


TRIAD SP-5
GROUP III
(Min, Mean, Max)
3760
3740
3720
3700
3680
3660
3640
3620
3600
3580
3560
3540
3520
3500
3480
3460
3440
3420
3400
Initial
Solder Dip
Lead Pull + Twist
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

PRIMARY DCR

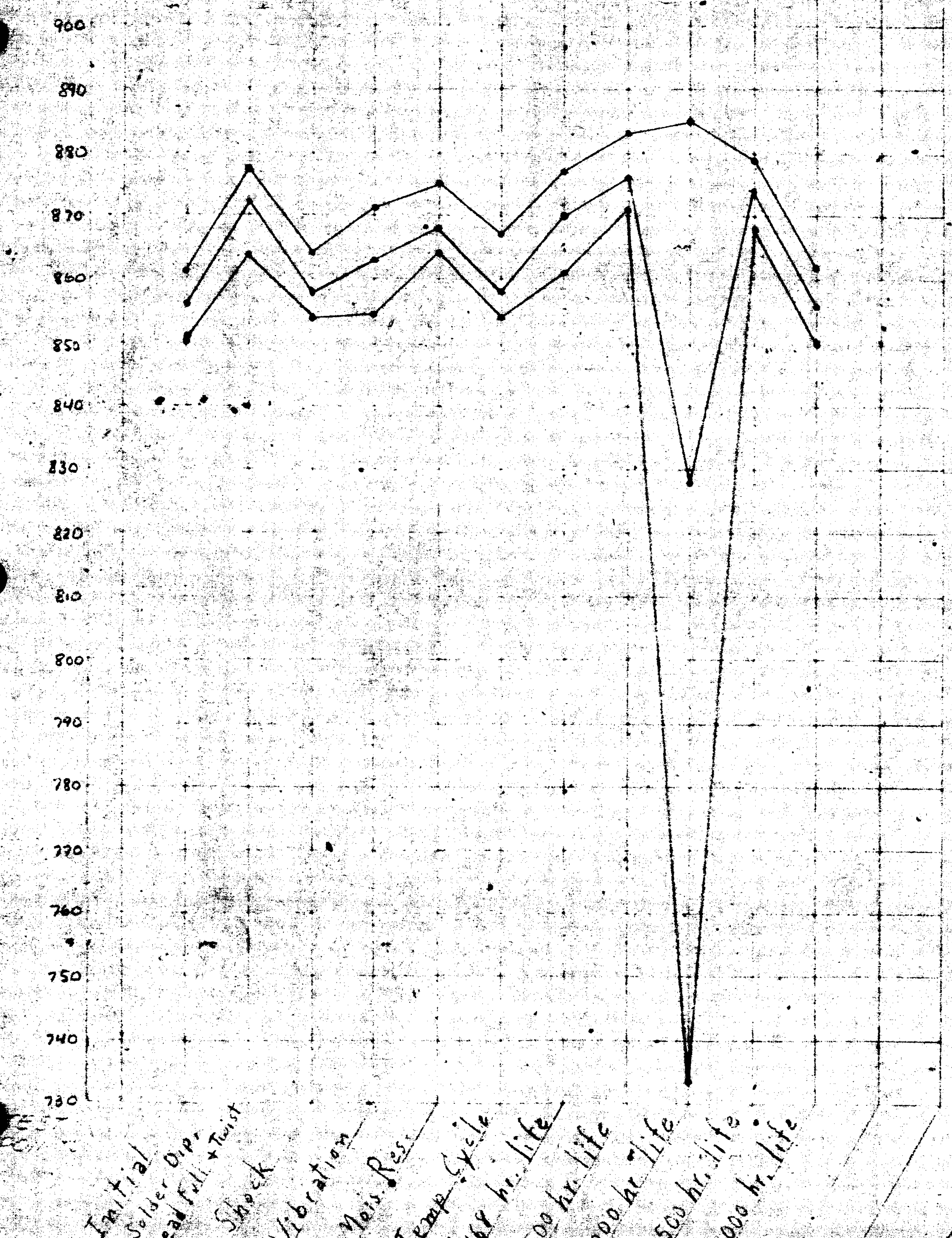
TRIAD SP-66 GROUP III (Min, Mean, Max)

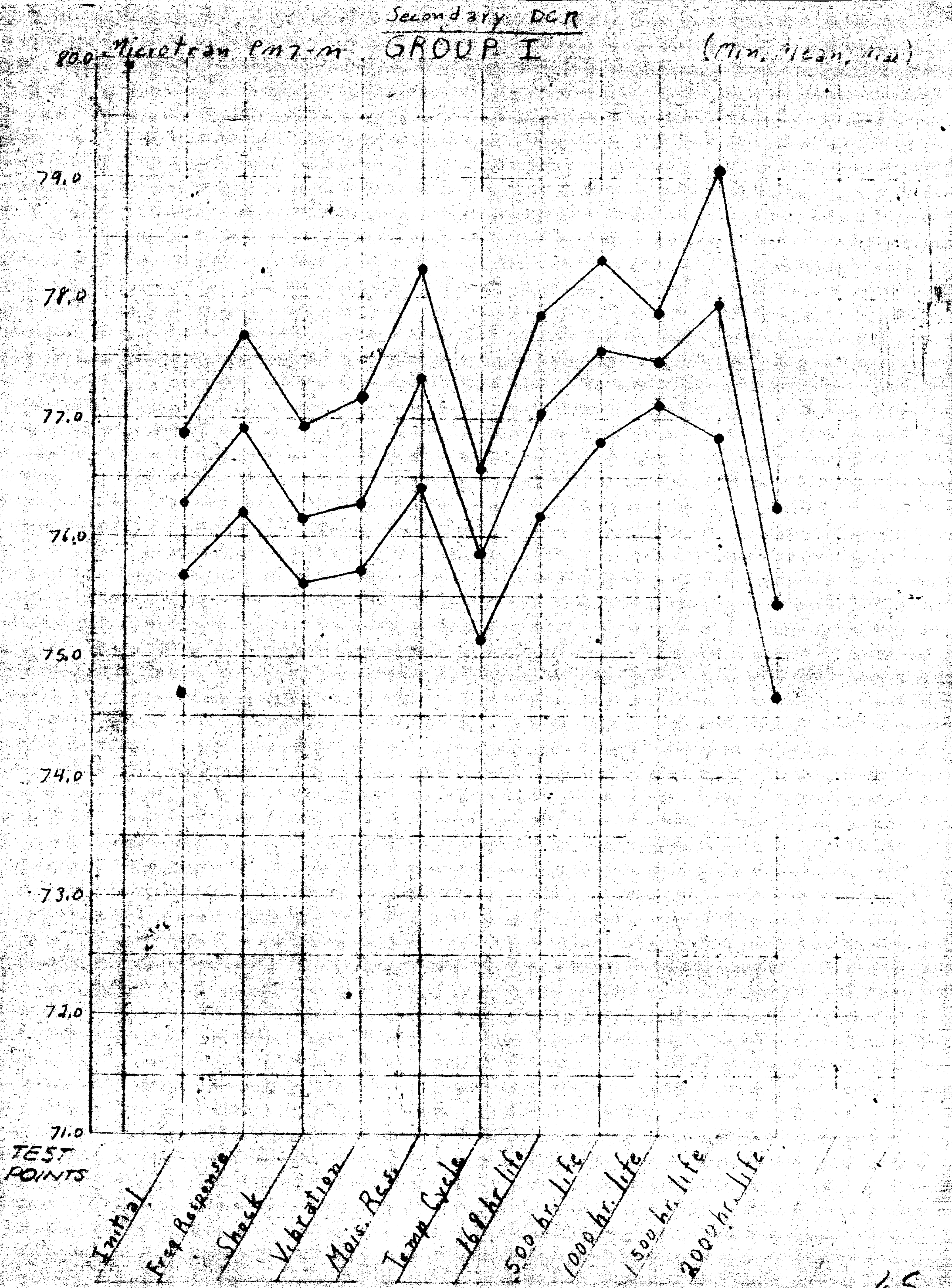


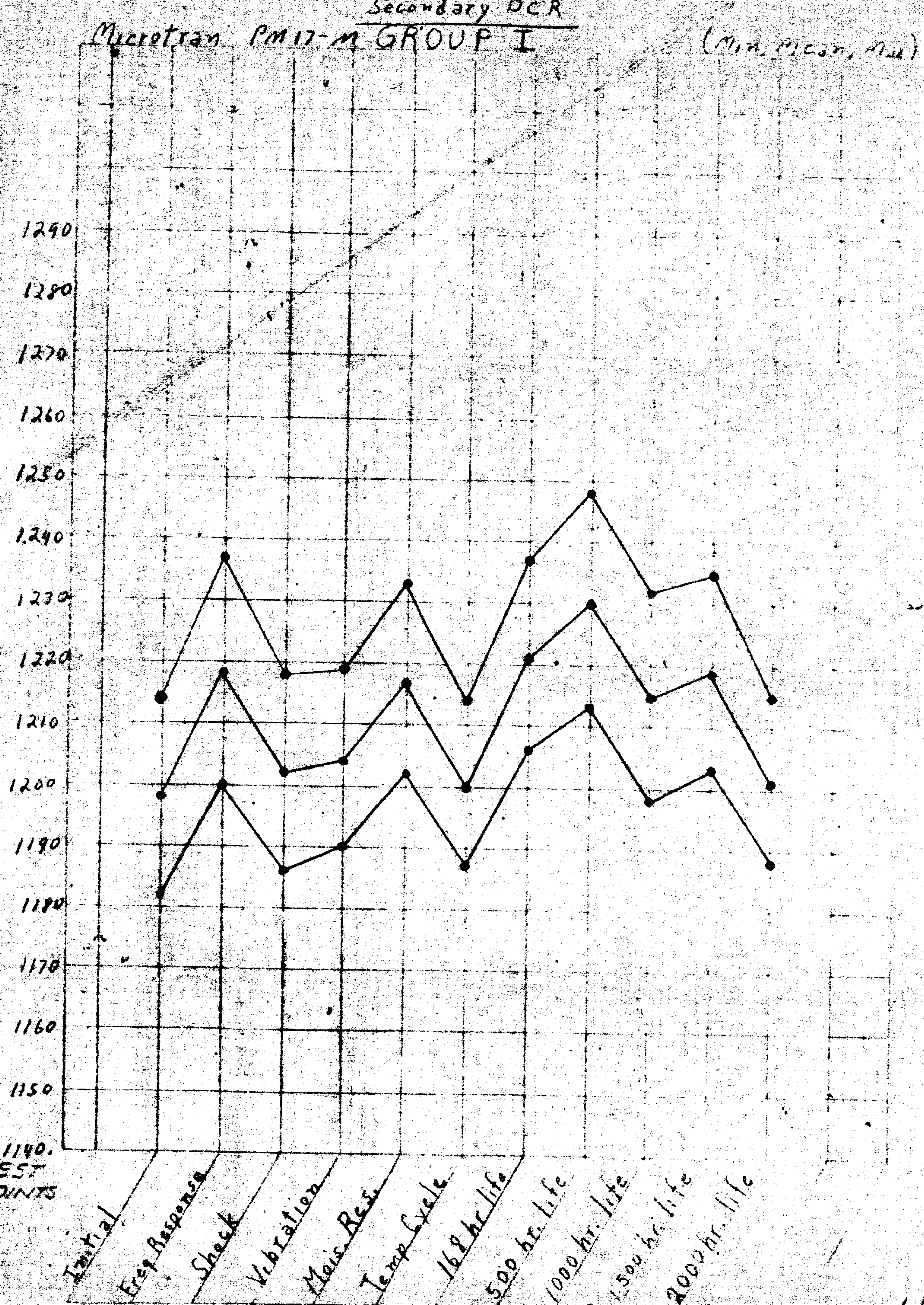

PRIMARY DER
GROUP III
UTC DO-T10
(Min, Mean, Max.)
800
790
780
770
760
750
740
730
720
710
700
690
680
670
Initial
Solder Dip, Lead Pull + Twist
Shock
Vibration
Mois. Res
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1,500 hr. life
2,000 hr. life

PRIMARY DCR

UTC DO-T36 GROUP III (Min, Mean, Max)

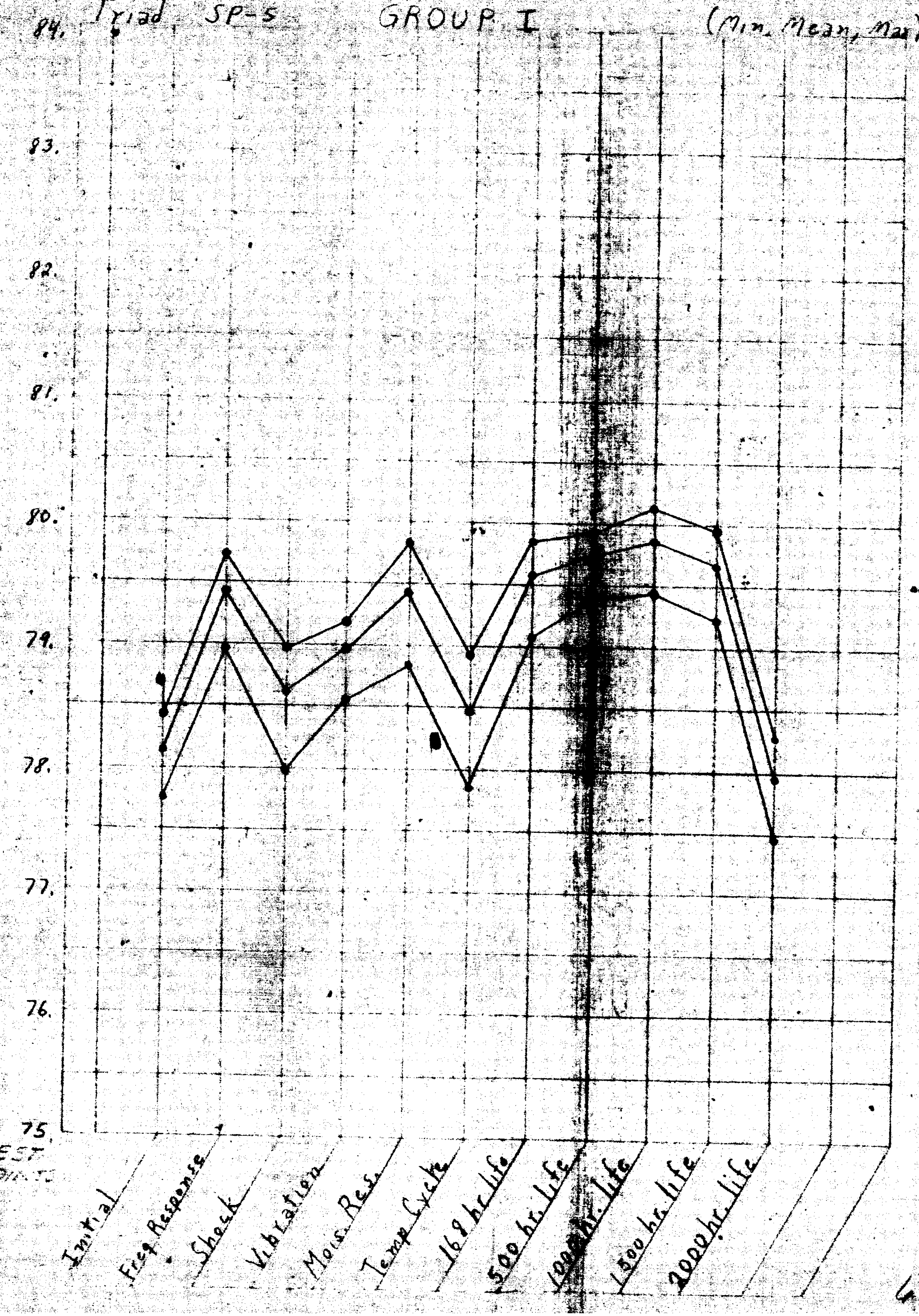


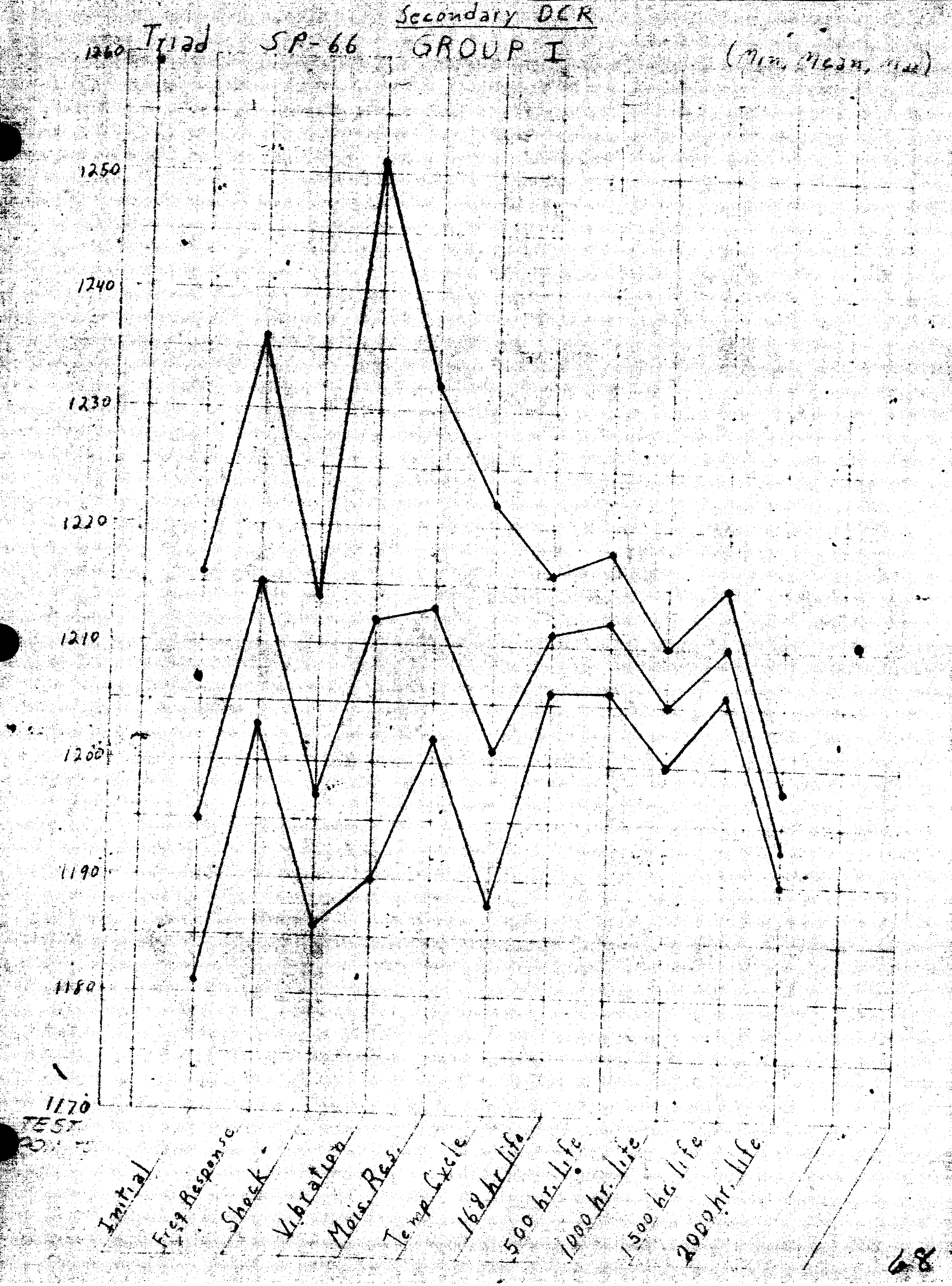

Secondary DCR
Microtran PM7-M GROUP I
(Min, Mean, Max)
80.0
79.0
78.0
77.0
76.0
75.0
74.0
73.0
72.0
71.0
TEST POINTS
Initial
Freq. Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

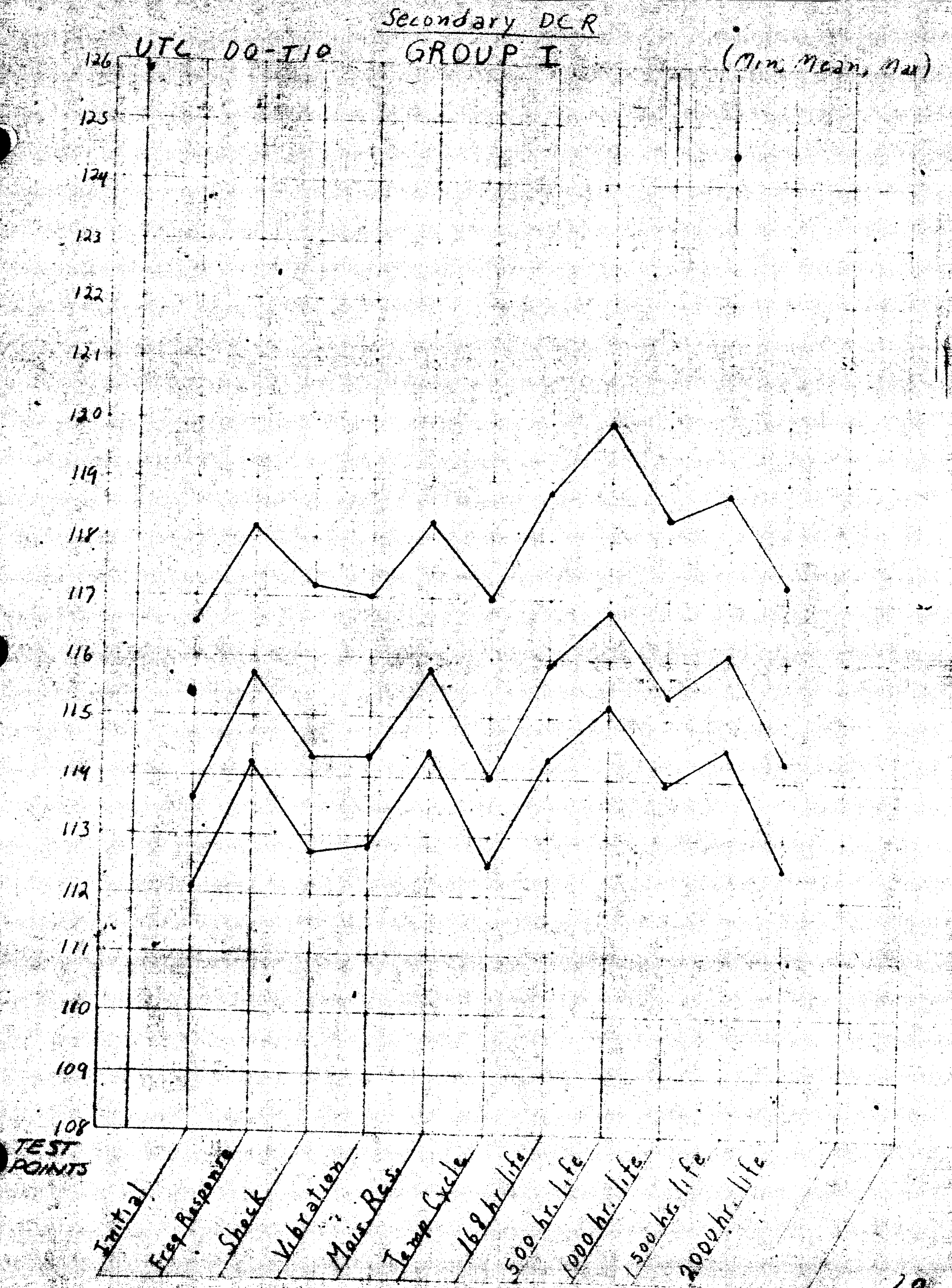


Secondary DCR
Microtran PM17-M GROUP I
(Min, Mean, Max)
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140.
TEST POINTS
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

Secondary DCR



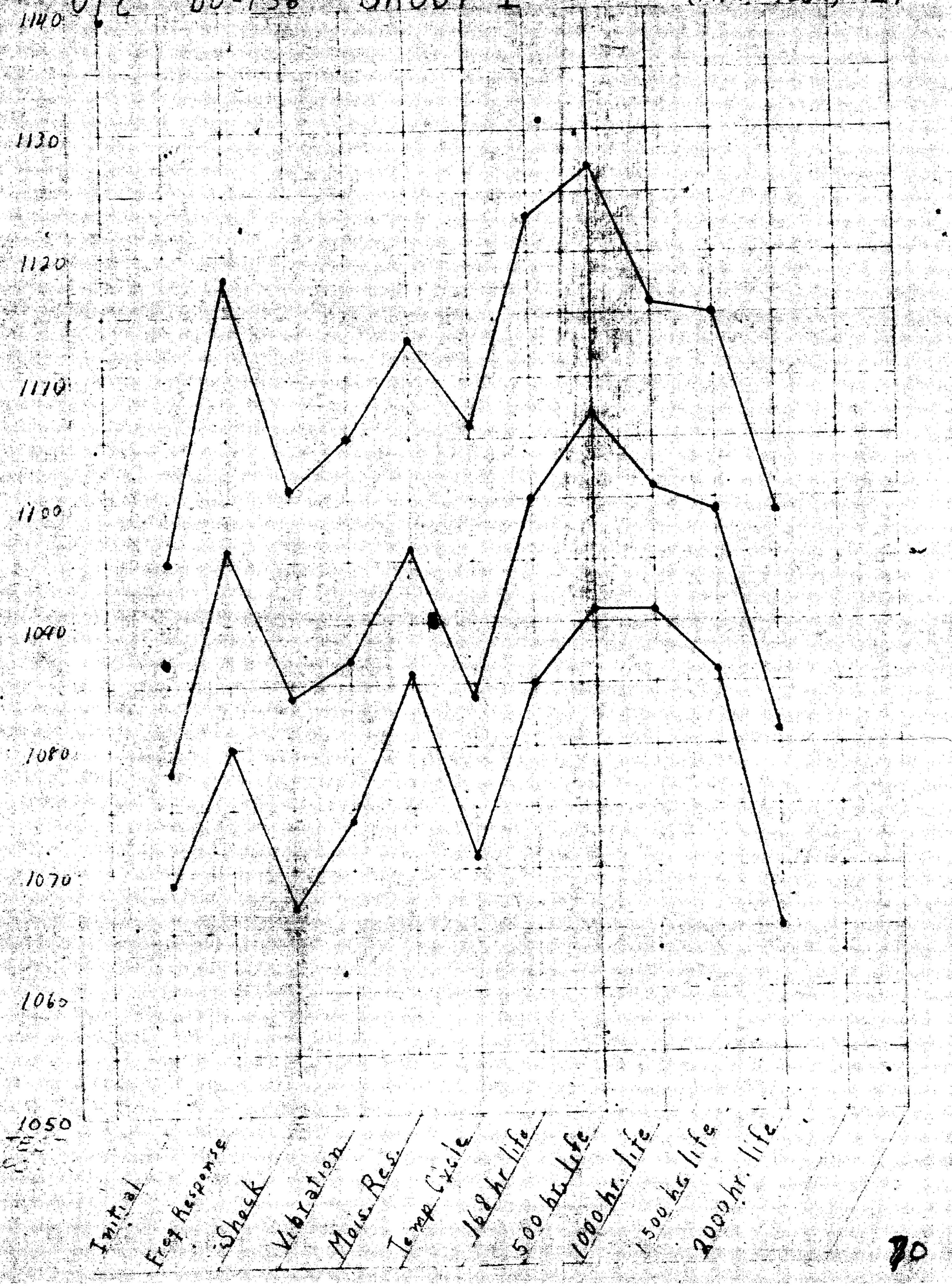

Secondary DCR
Triad SP-66 GROUP I
(Min, Mean, Max)
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
TEST
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr life
500 hr. Life
1000 hr. life
1500 hr. life
2000 hr. life

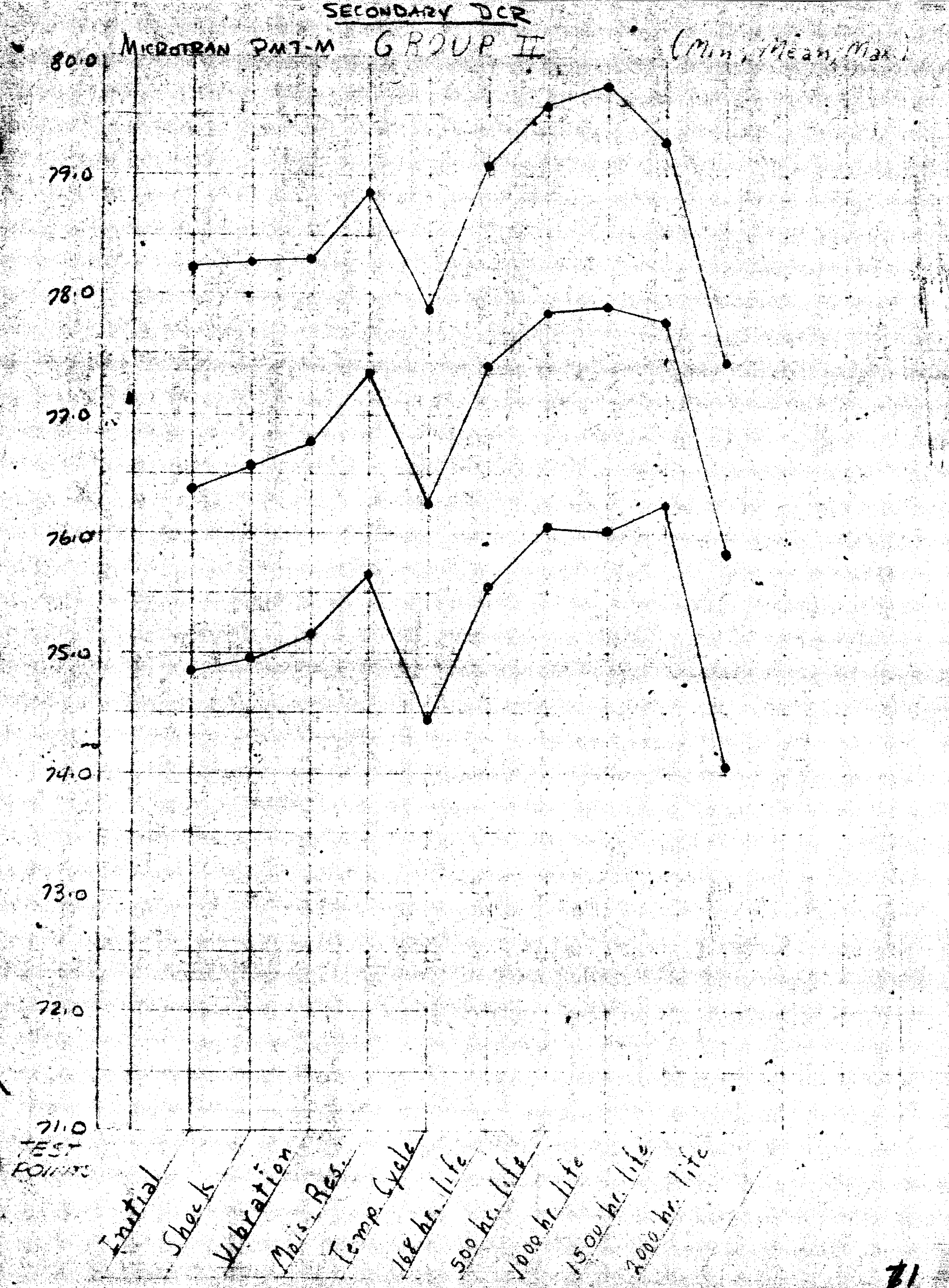


Secondary DCR
UTC DO-T10
GROUP I
(Min, Mean, Max)
126
125
124
123
122
121
120
119
118
117
116
115
114
113
112
111
110
109
108
TEST POINTS
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

Secondary DCR

UTC DO-T36 GROUP I (Min. Mean, Max)

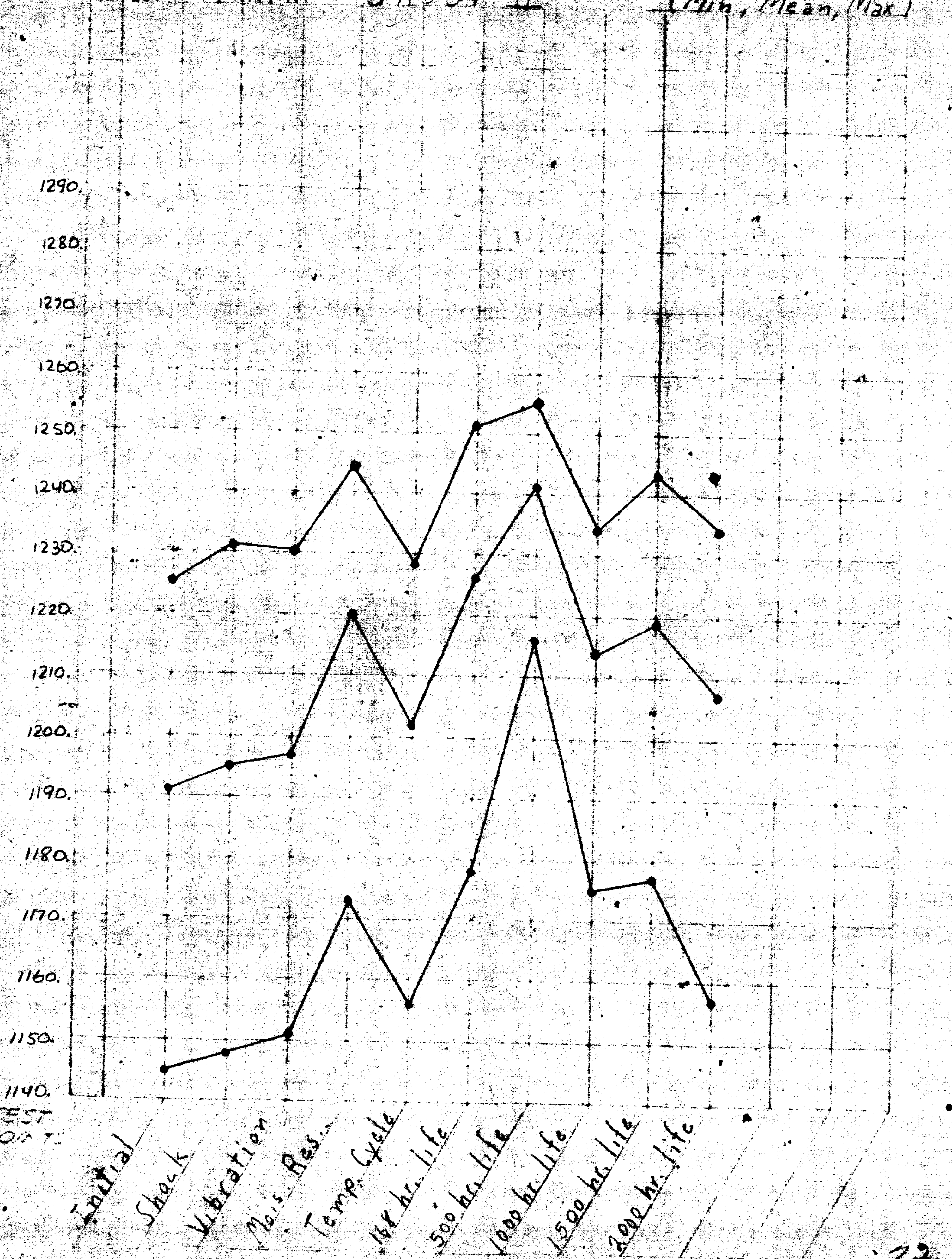


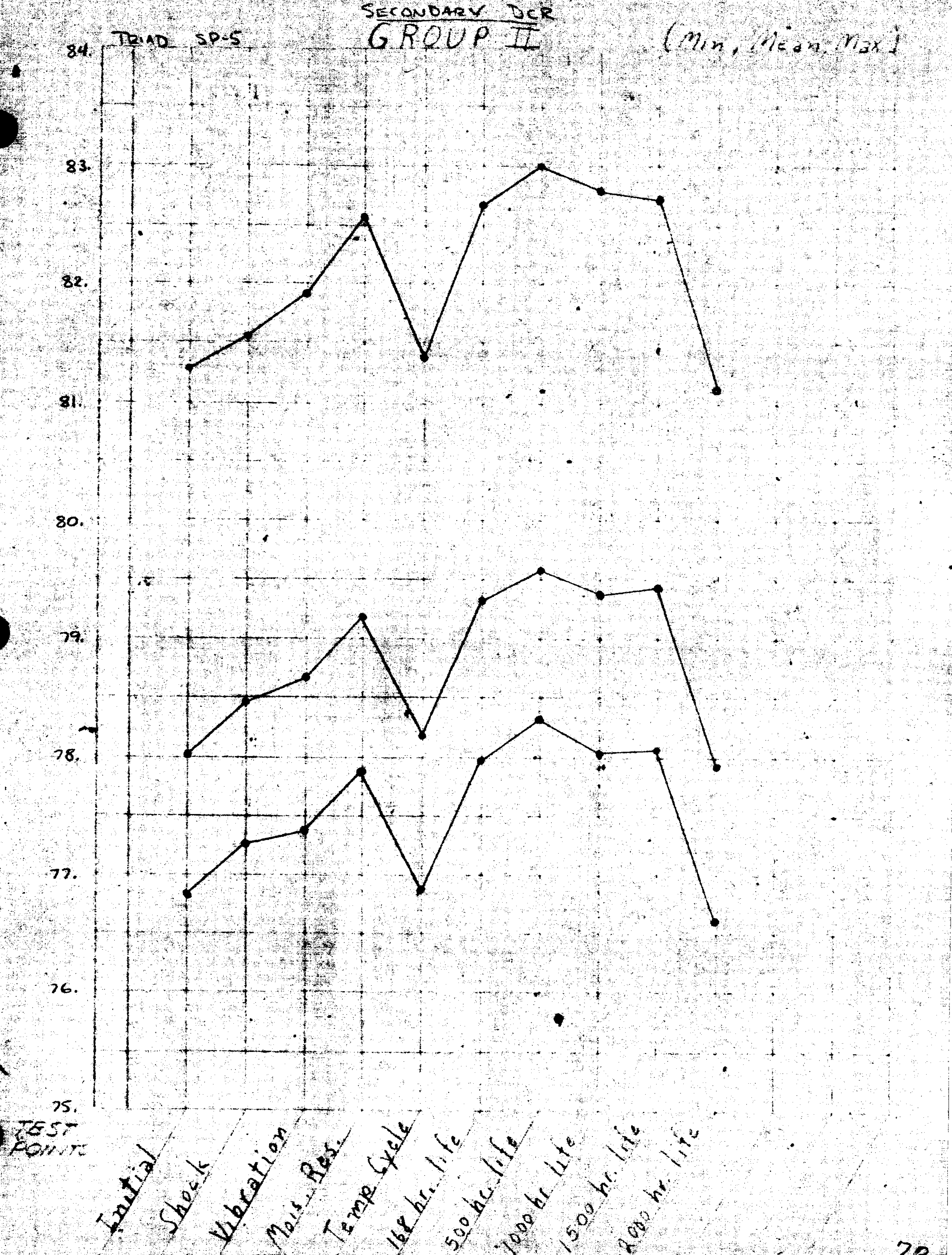


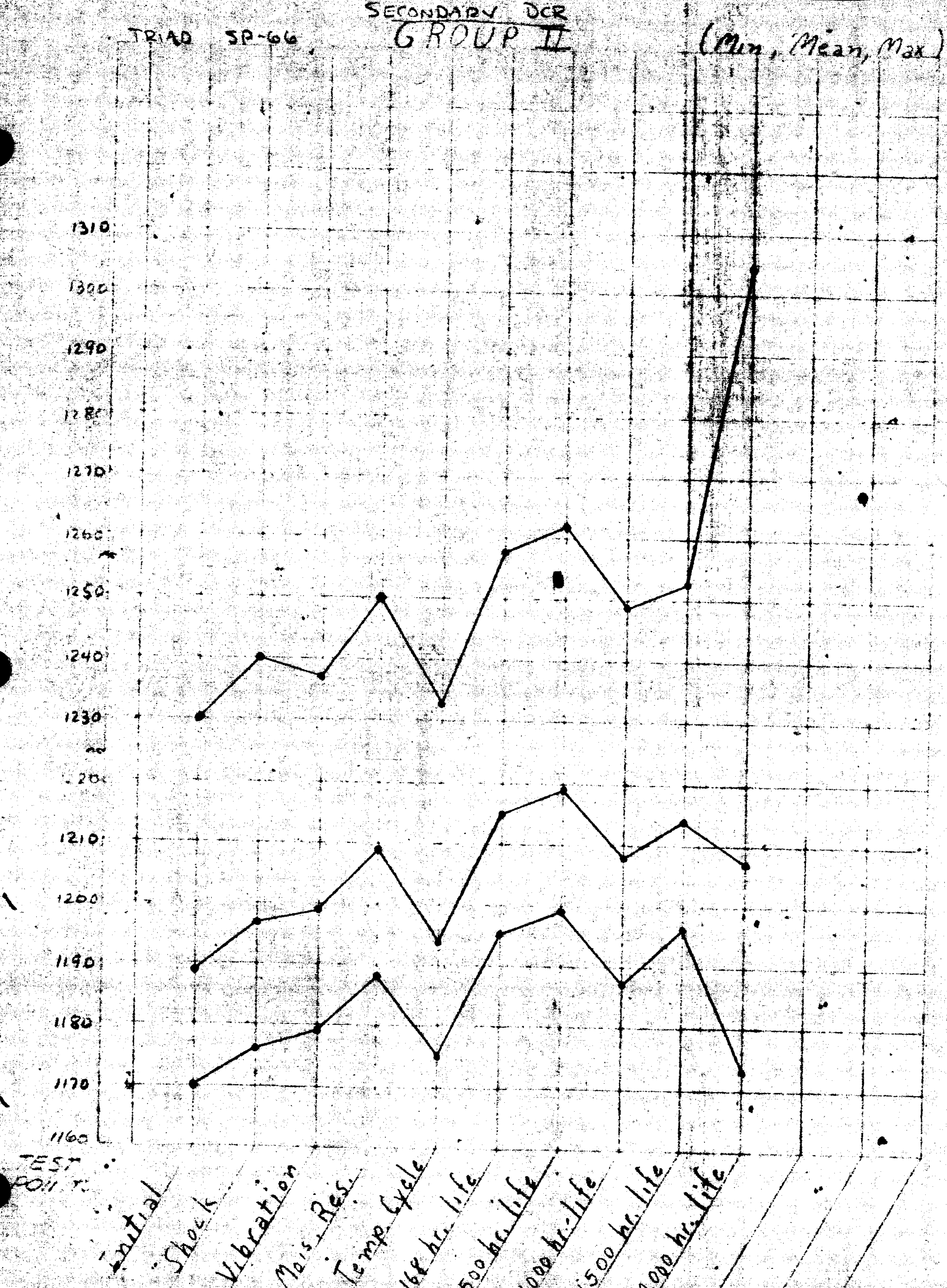
SECONDARY DCR
MICROTRAN PMT-M GROUP II
(Min, Mean, Max)
80.0
79.0
78.0
77.0
76.0
75.0
74.0
73.0
72.0
71.0
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

SECONDARY DCR

MICROTRAN PM12-M GROUP II (Min, Mean, Max)

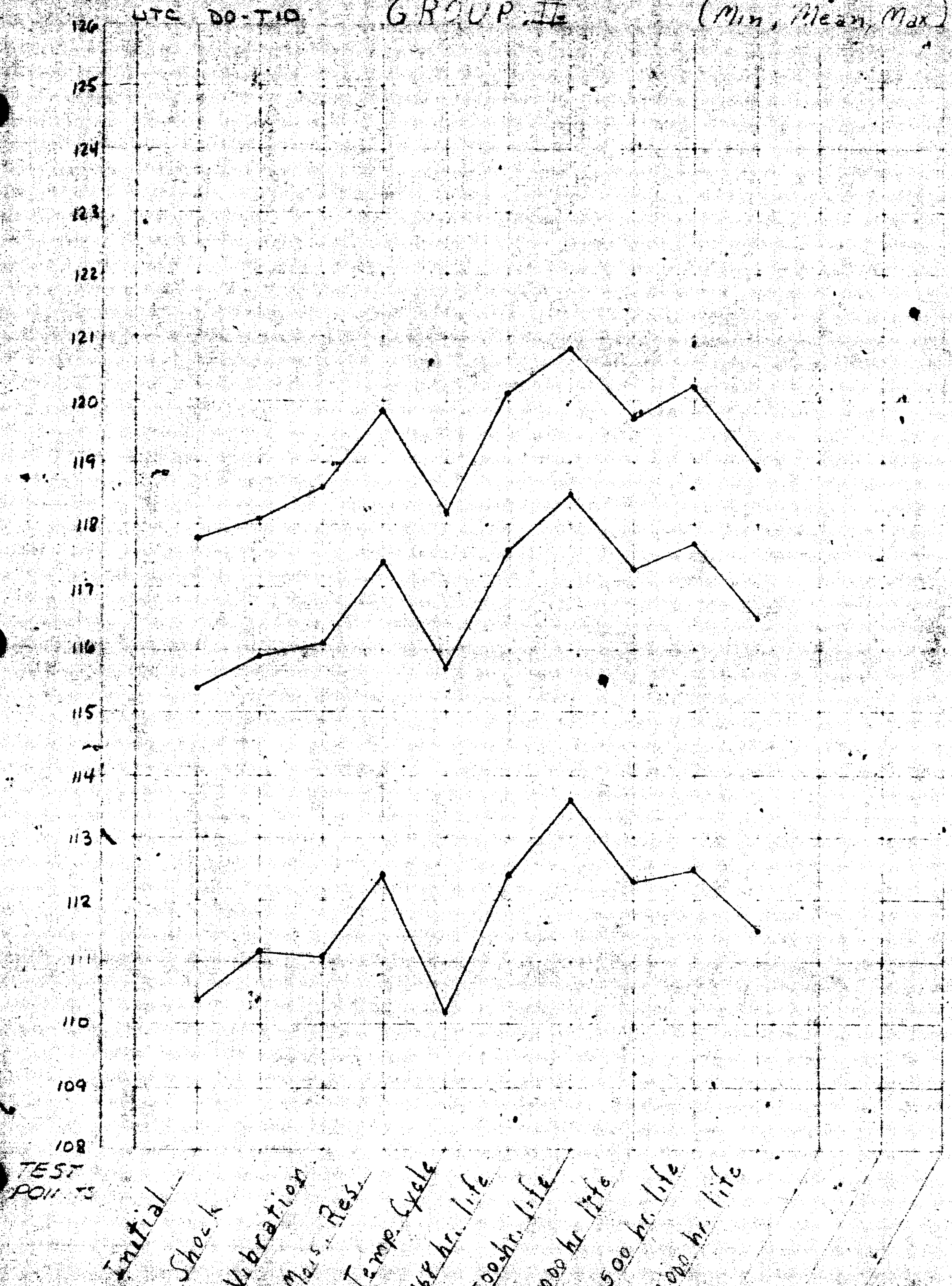


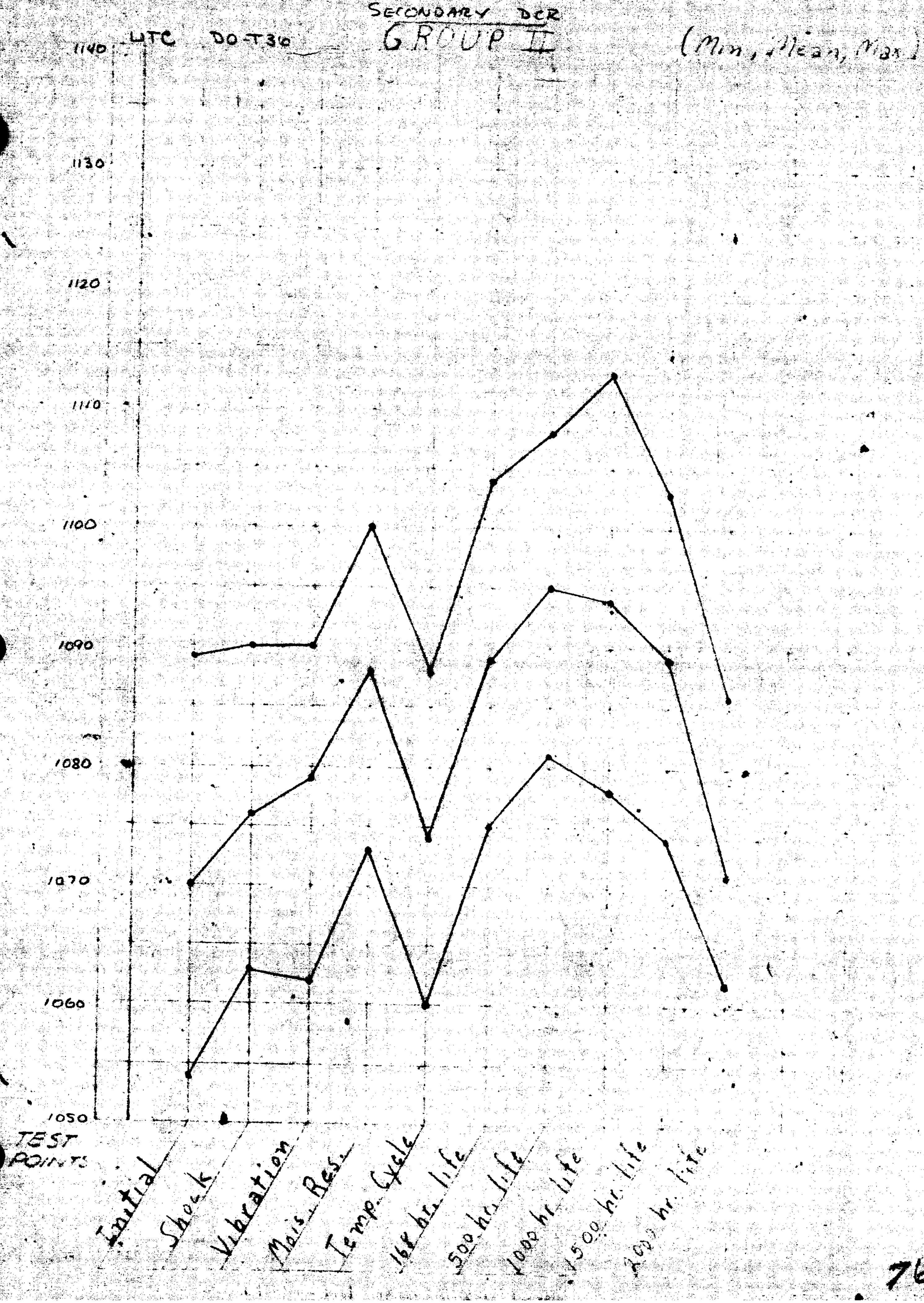

SECONDARY DCR
GROUP II
TRIAD SP-5
(Min, Mean, Max)
84.
83.
82.
81.
80.
79.
78.
77.
76.
75.
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life



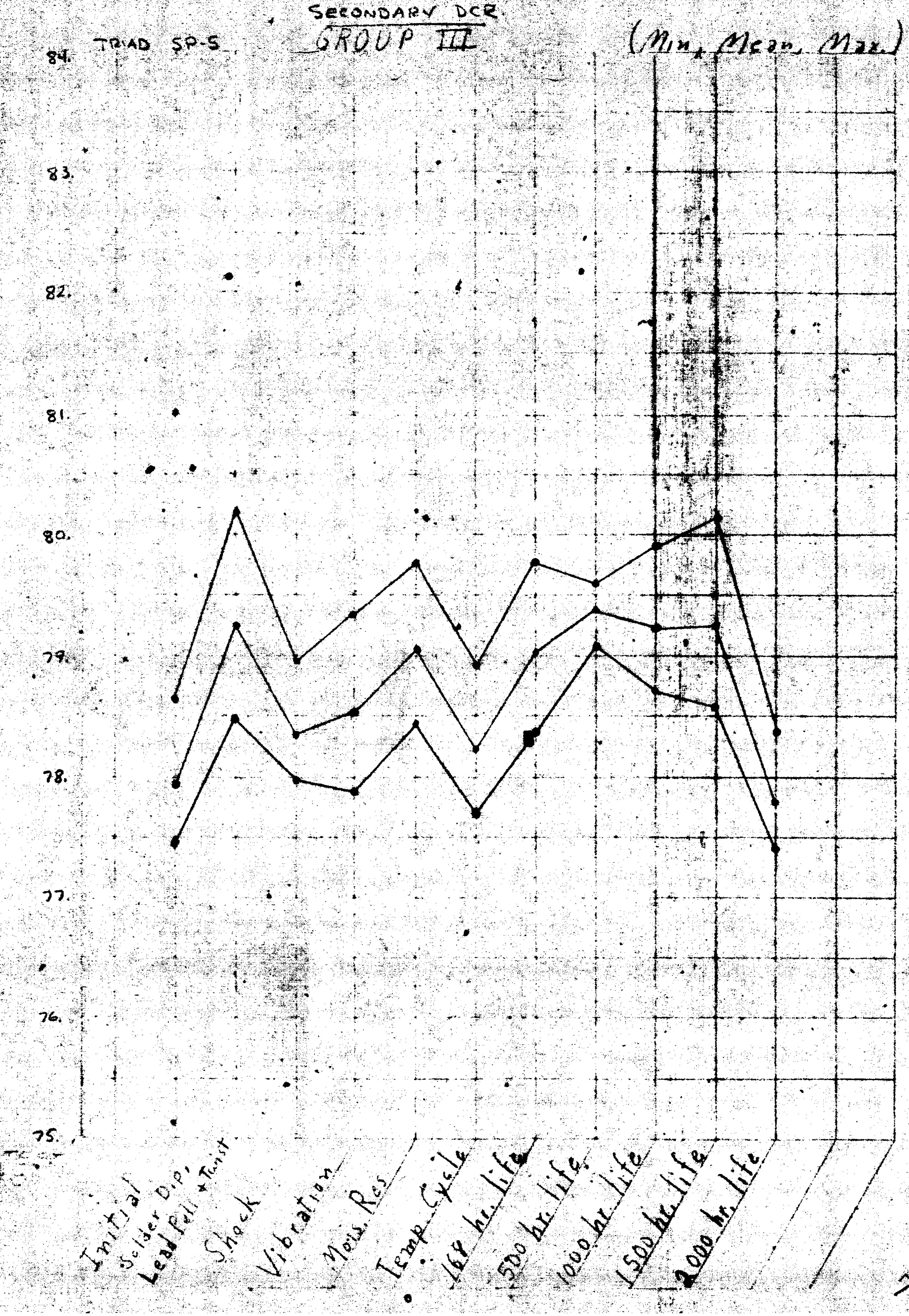
SECONDARY DCR
TRIAD SP-66
GROUP II
(Min, Mean, Max)
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

SECONDARY DCR

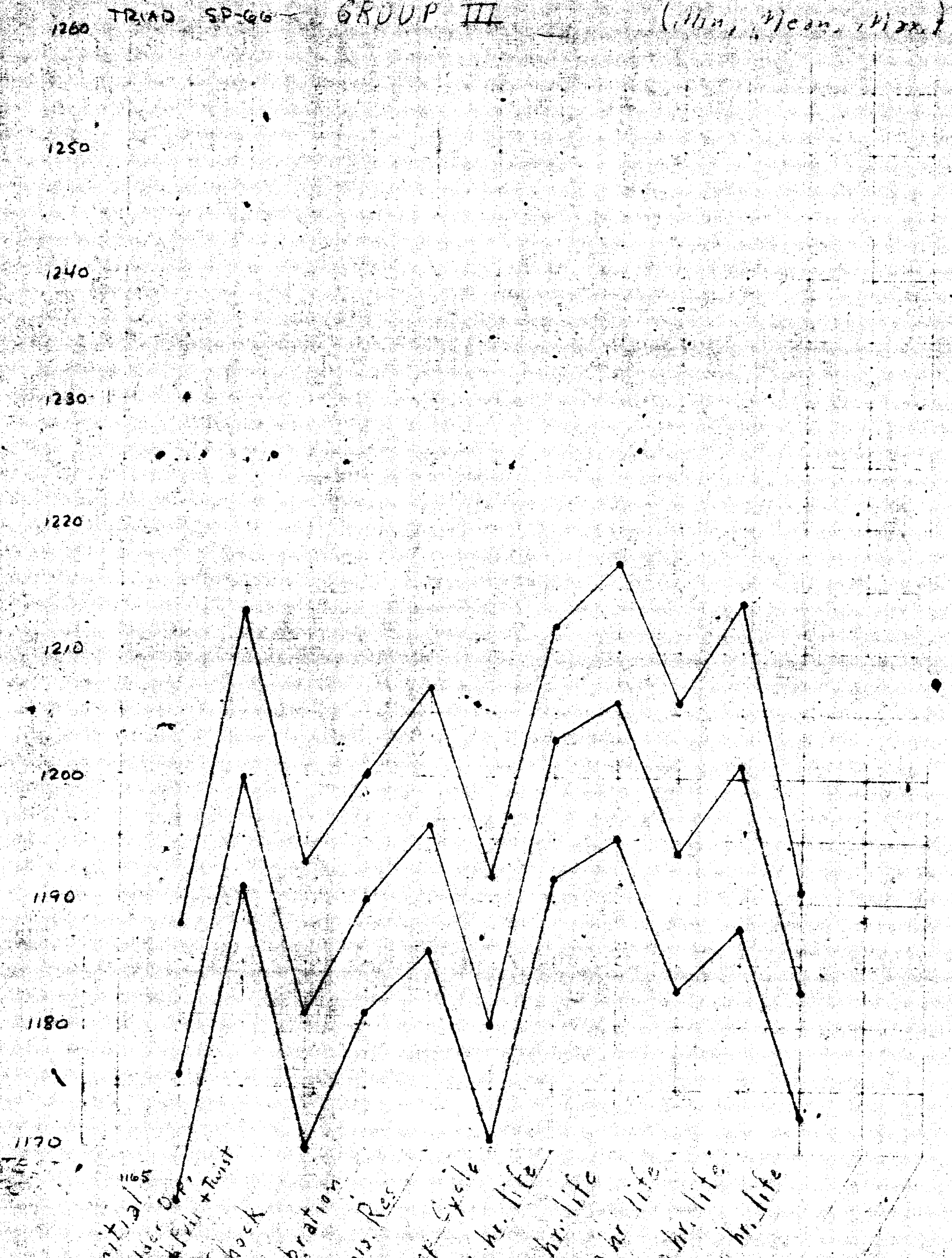


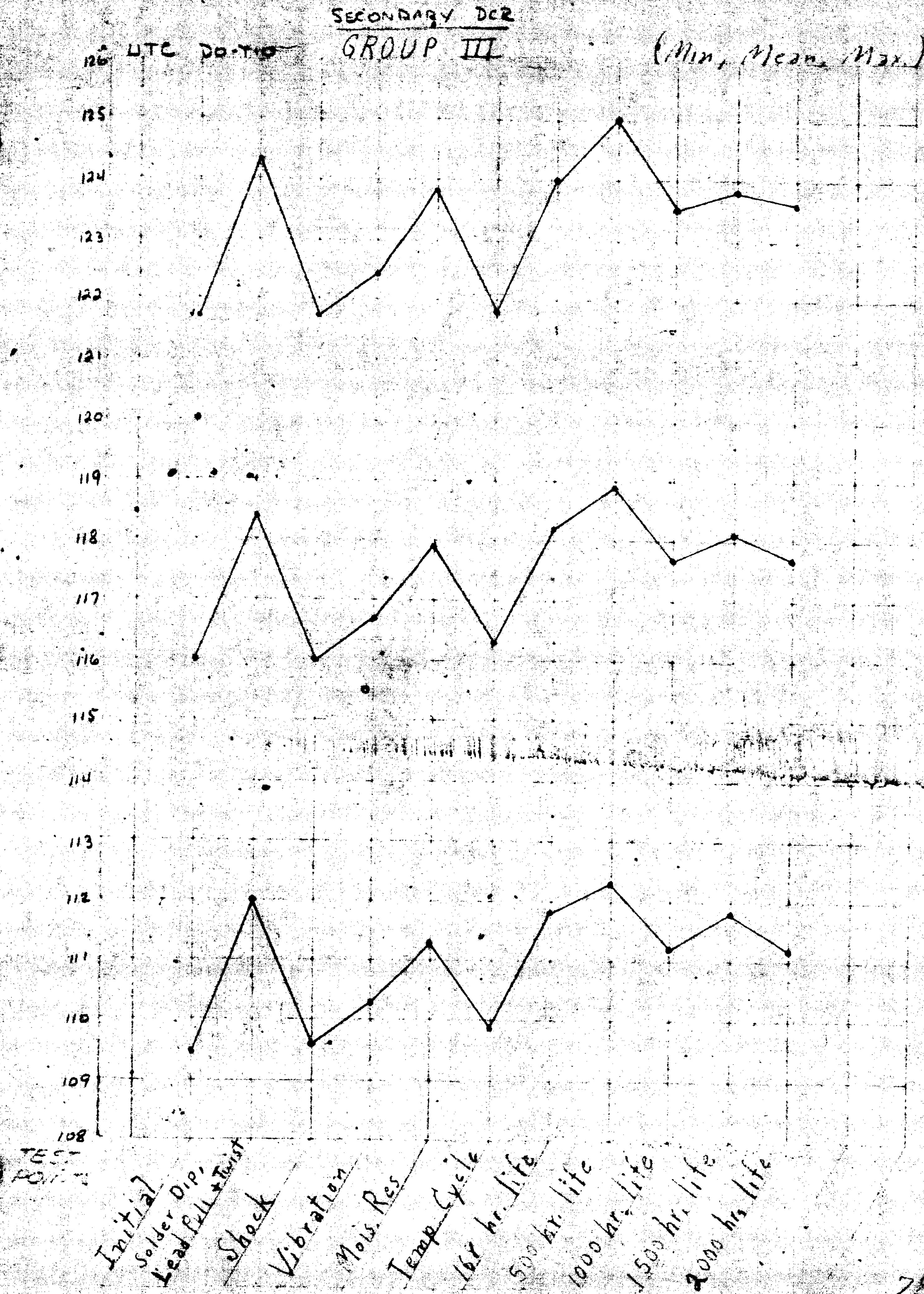


SECONDARY DCR
UTC DO-T30
GROUP II
(Min, Mean, Max)
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

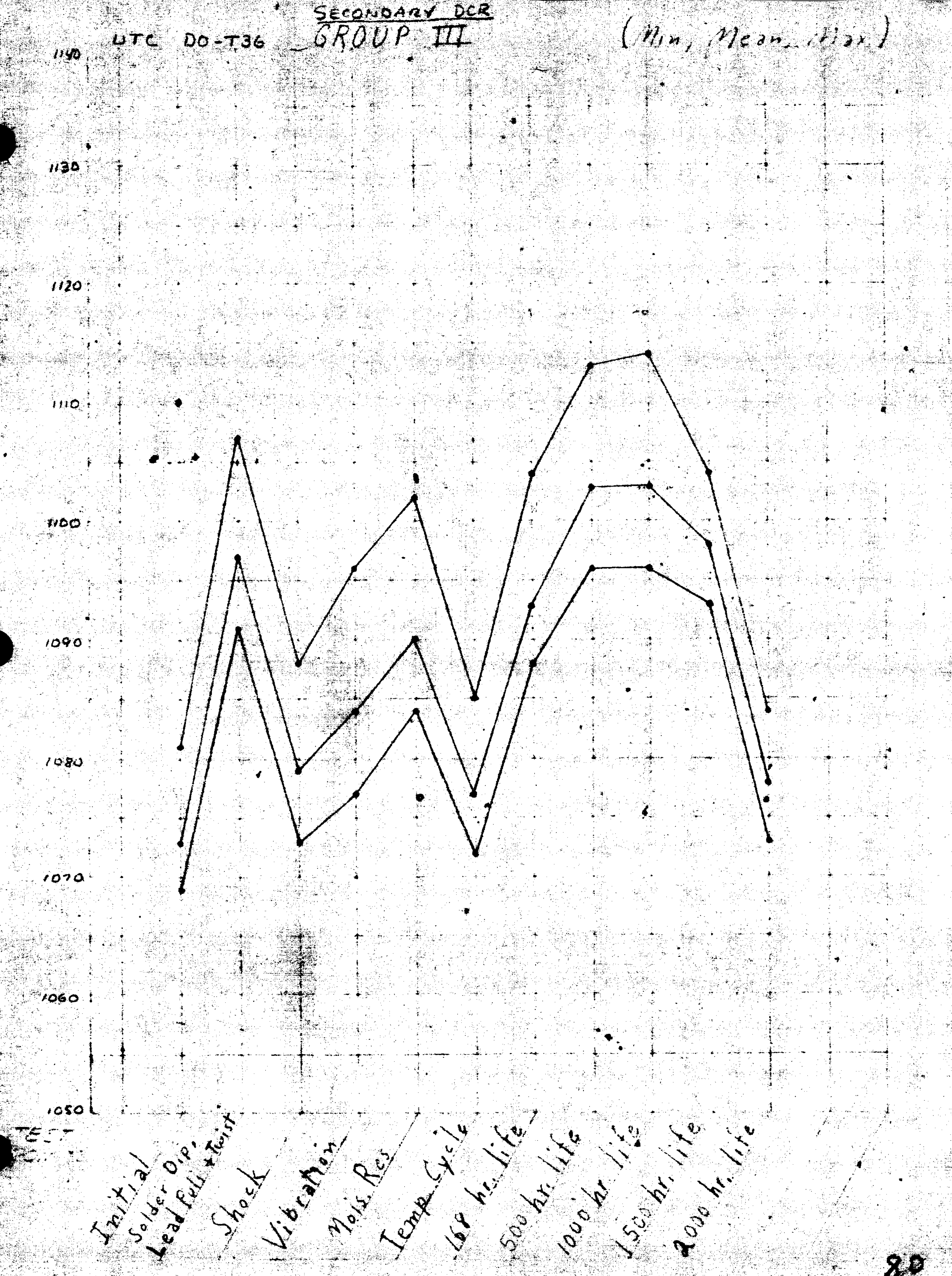

SECONDARY DCR
TRIAD SP-5
GROUP III
(Min, Mean, Max)
84.
83.
82.
81.
80.
79.
78.
77.
76.
75.
Initial
Solder Dip, Lead Pull + Twist
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

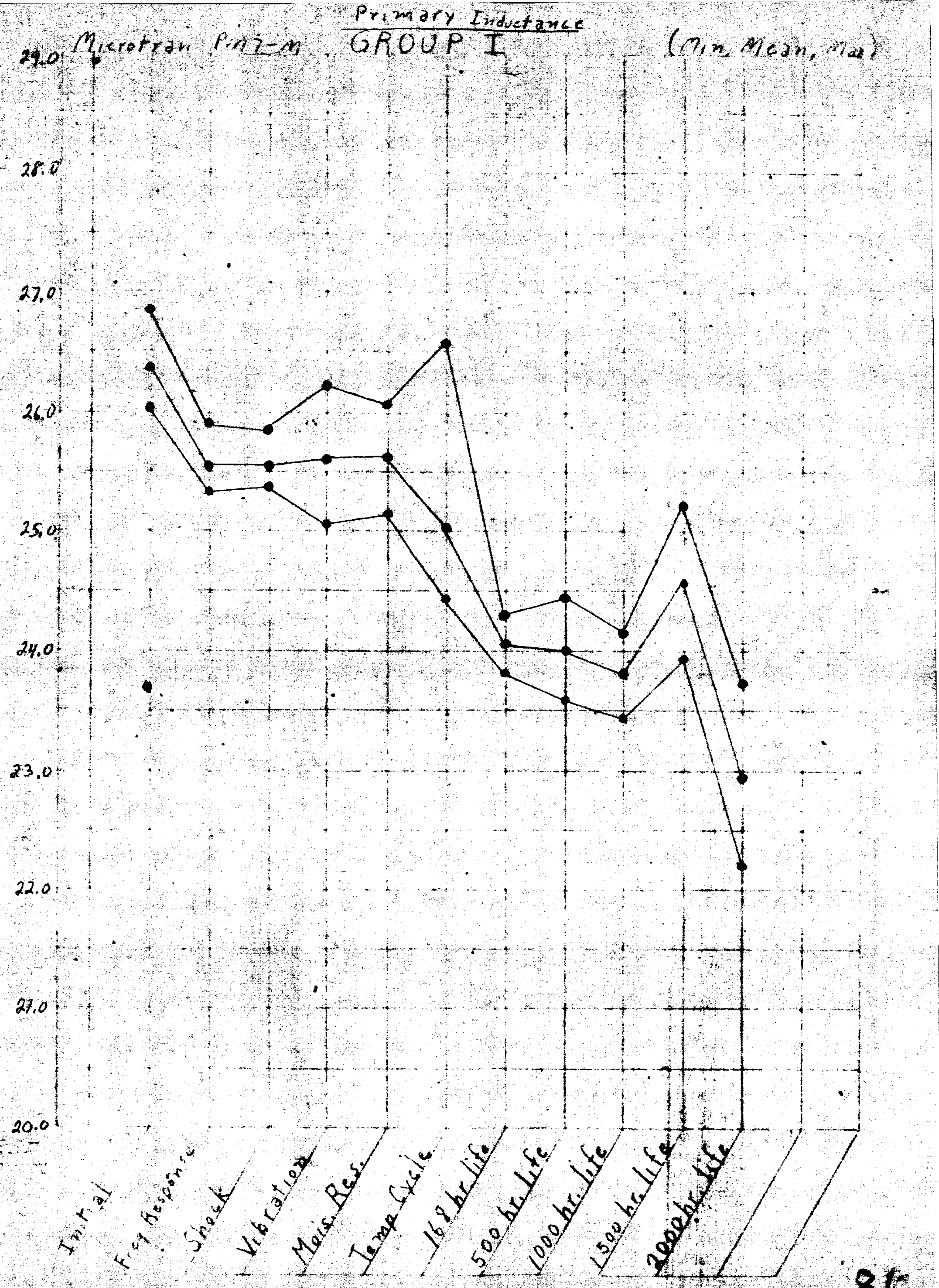
SECONDARY DCR





SECONDARY DCR
UTC DO-T10
GROUP III
(Min, Mean, Max.)
126
125
124
123
122
121
120
119
118
117
116
115
114
113
112
111
110
109
108
TEST POINT
Initial
Solder Dip, Lead Pull + Twist
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hrs life

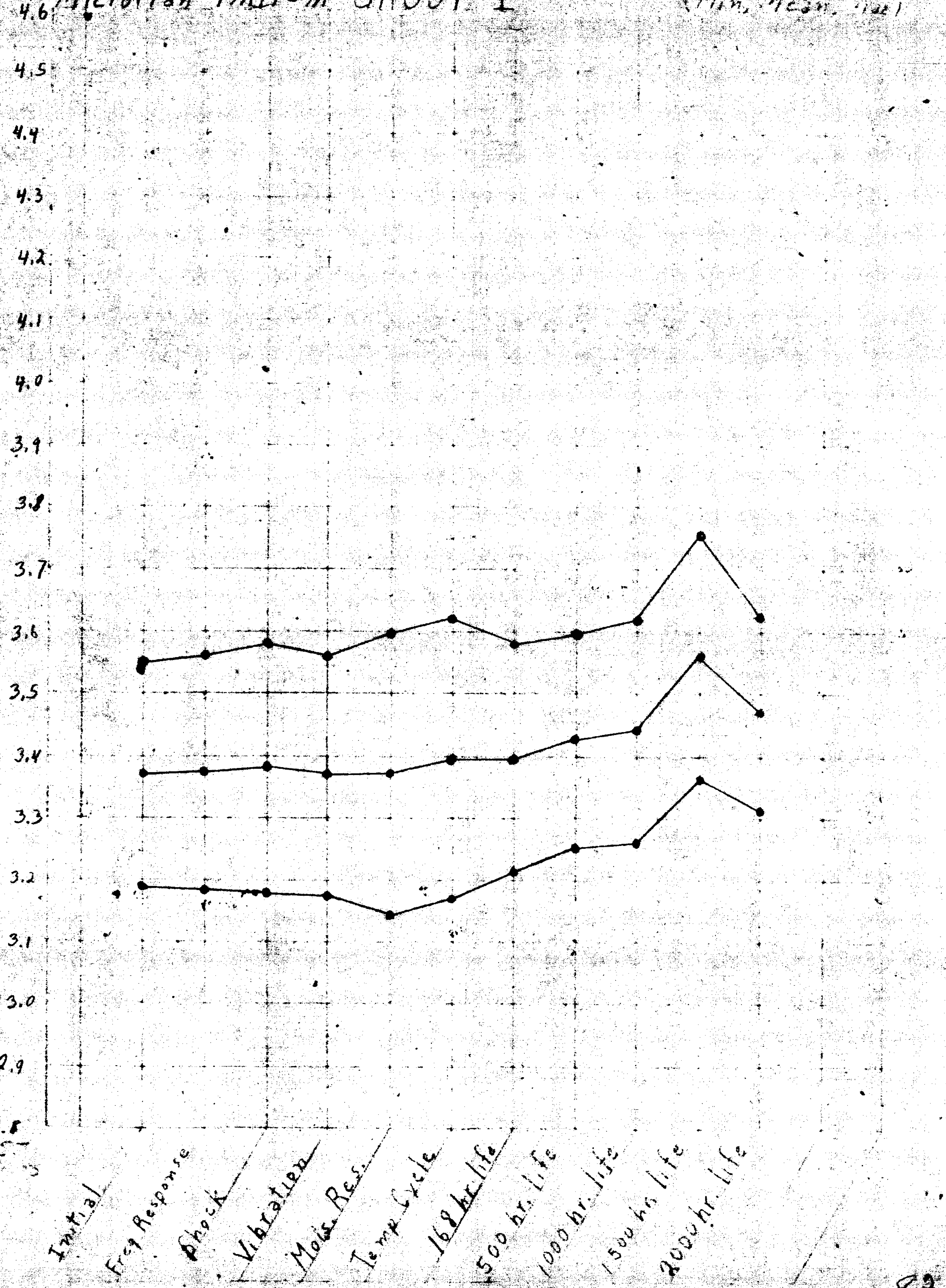

SECONDARY DCR
UTC DO-T36 GROUP III
(Min, Mean, Max)
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
TEST
Initial
Solder Dip.
Lead Pull + Twist
Shock
Vibration
Mois. Res
Temp Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

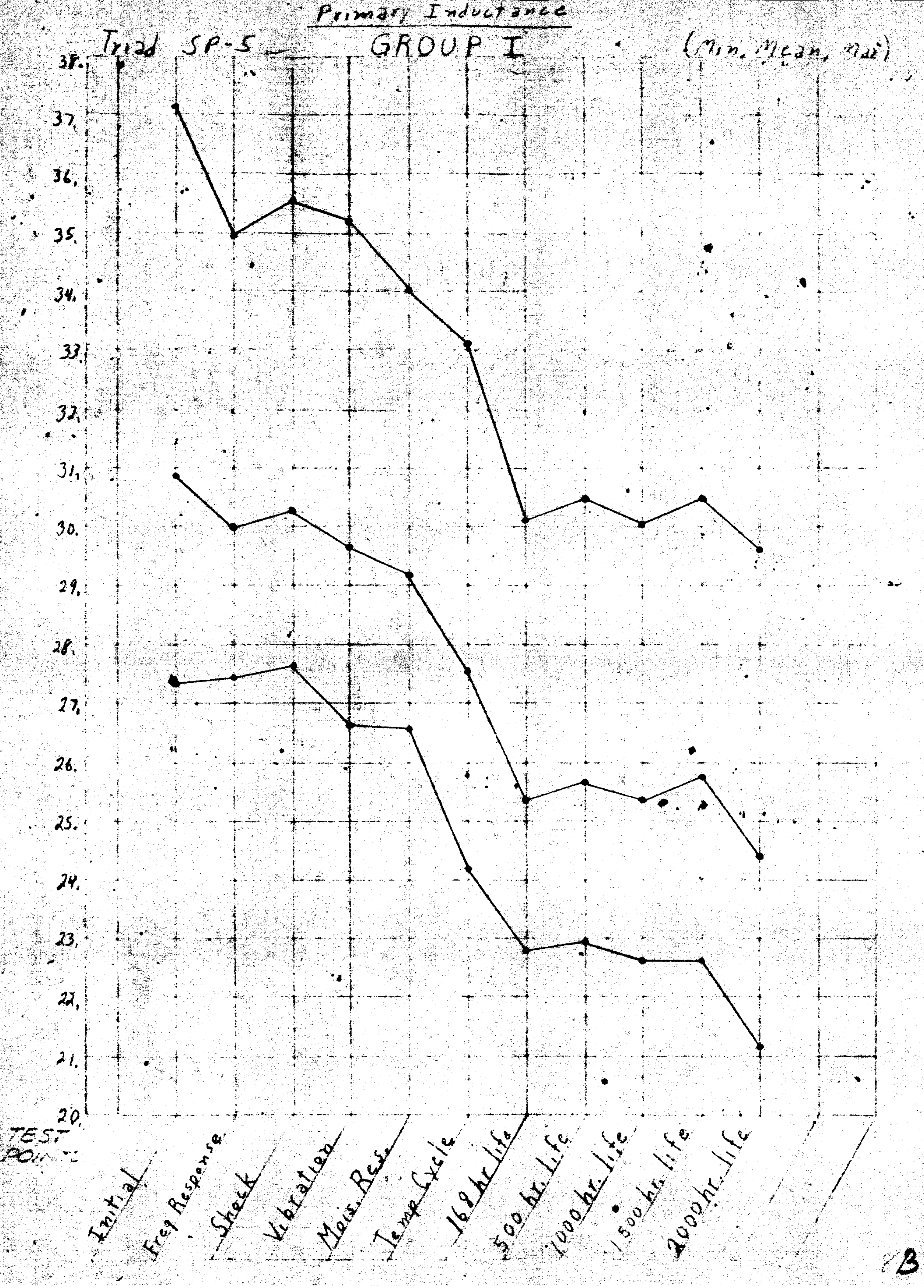


Primary Inductance
Microtran P-n7-M GROUP I
(Min, Mean, Max)
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

Primary Inductance

Microtran PM13-M GROUP I (Min, Mean, Max)

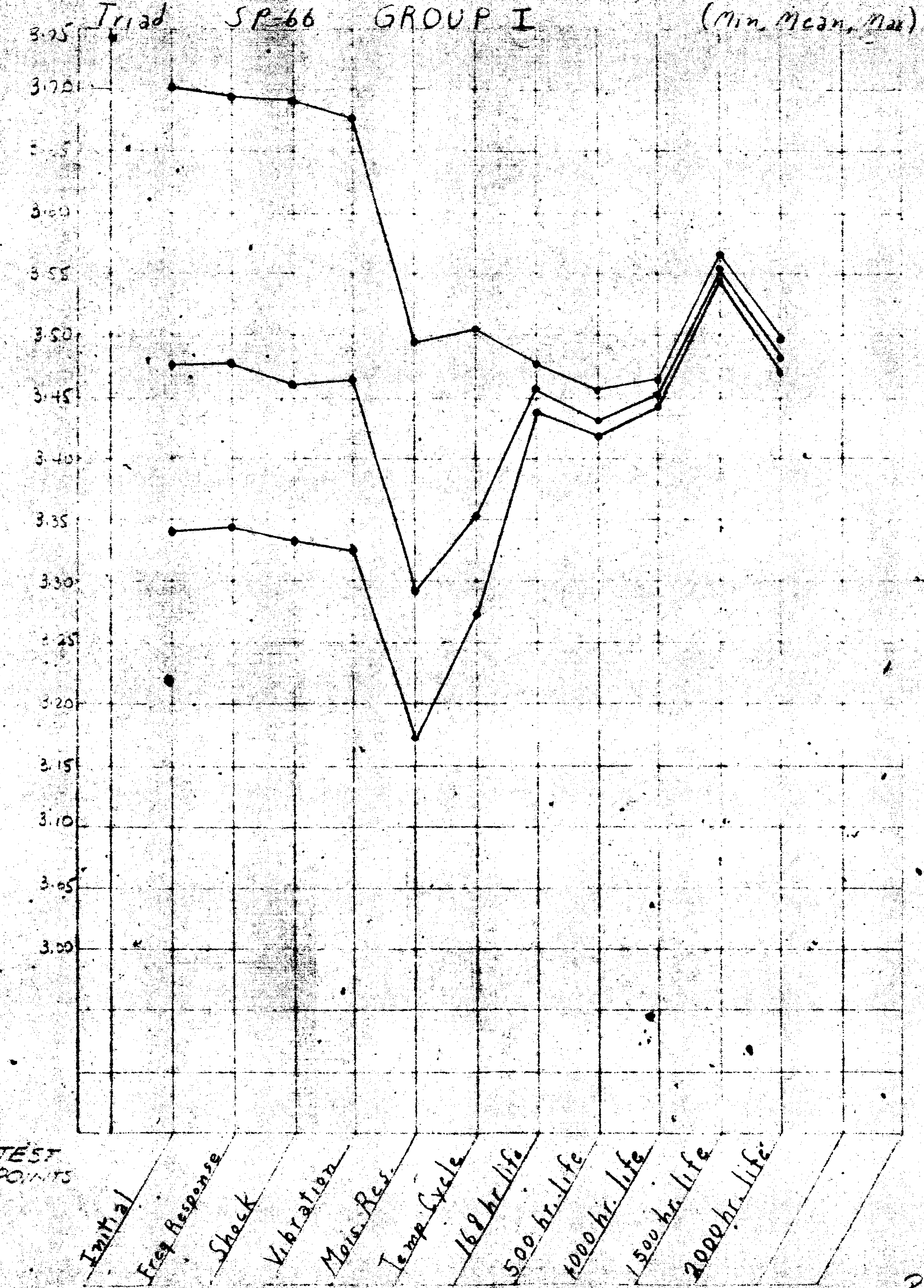


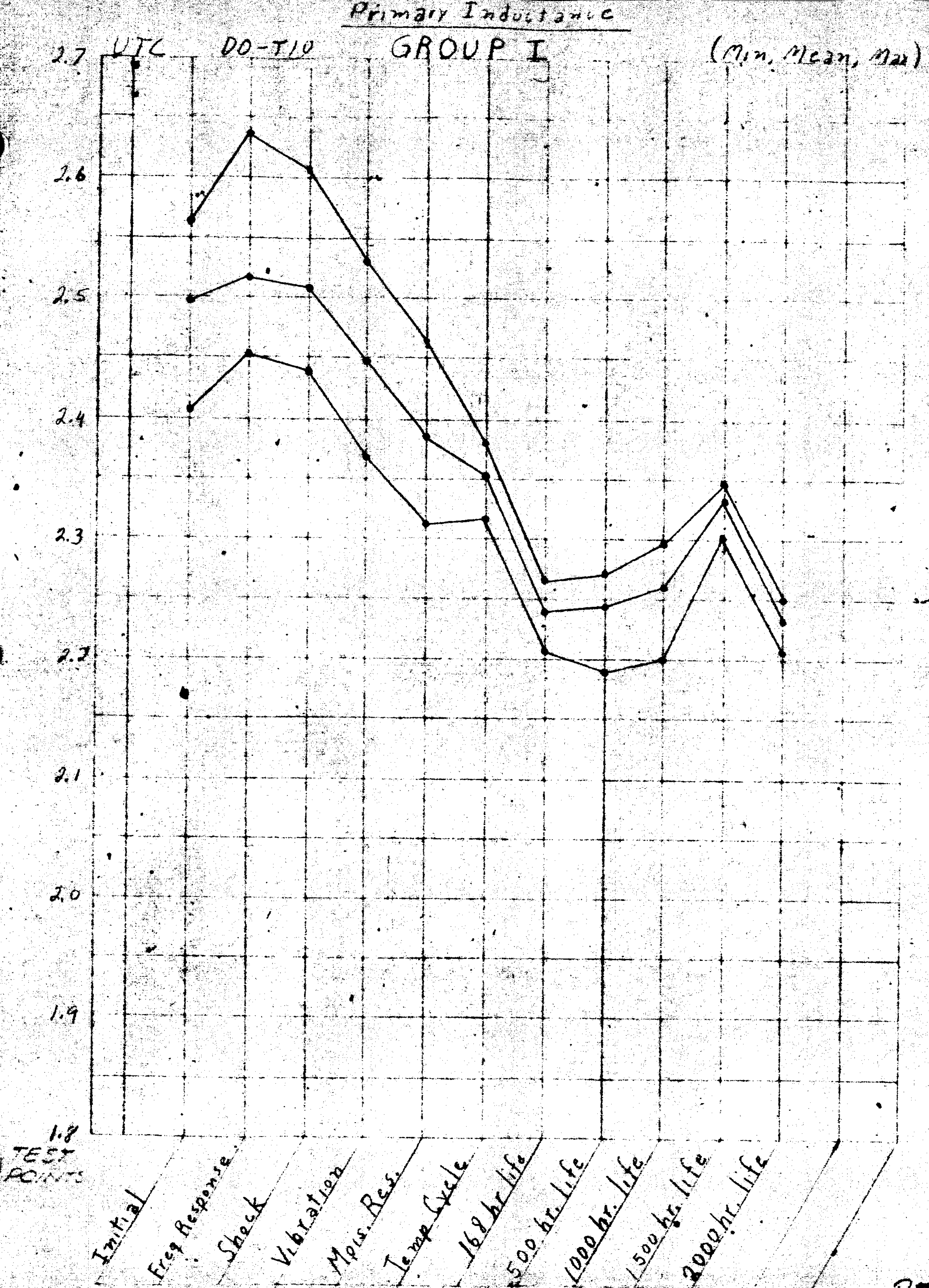


Primary Inductance
Triad SP-5
GROUP I
(Min, Mean, Max)
38.
37.
36.
35.
34.
33.
32.
31.
30.
29.
28.
27.
26.
25.
24.
23.
22.
21.
20.
TEST POINTS
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

83.

Primary Inductance

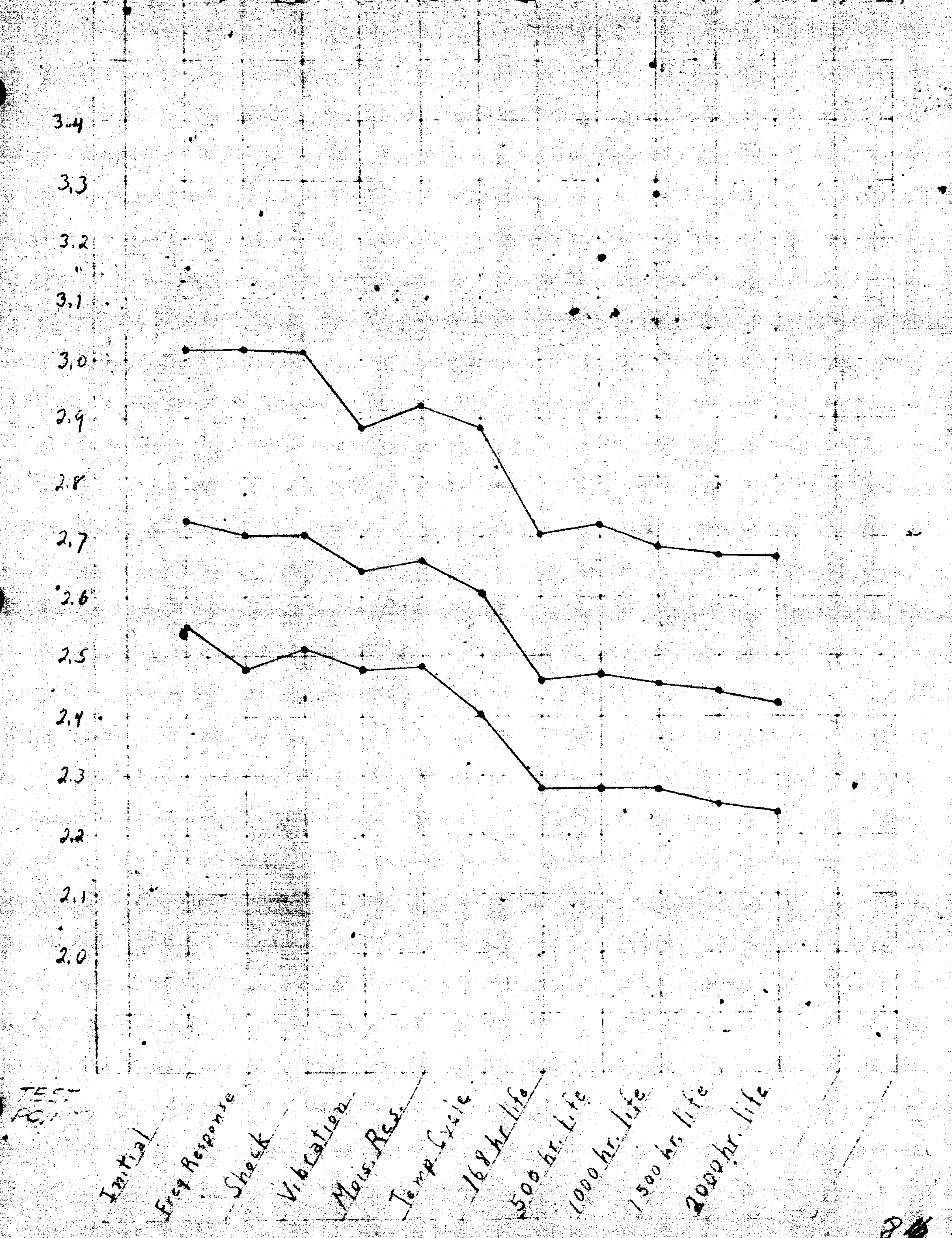


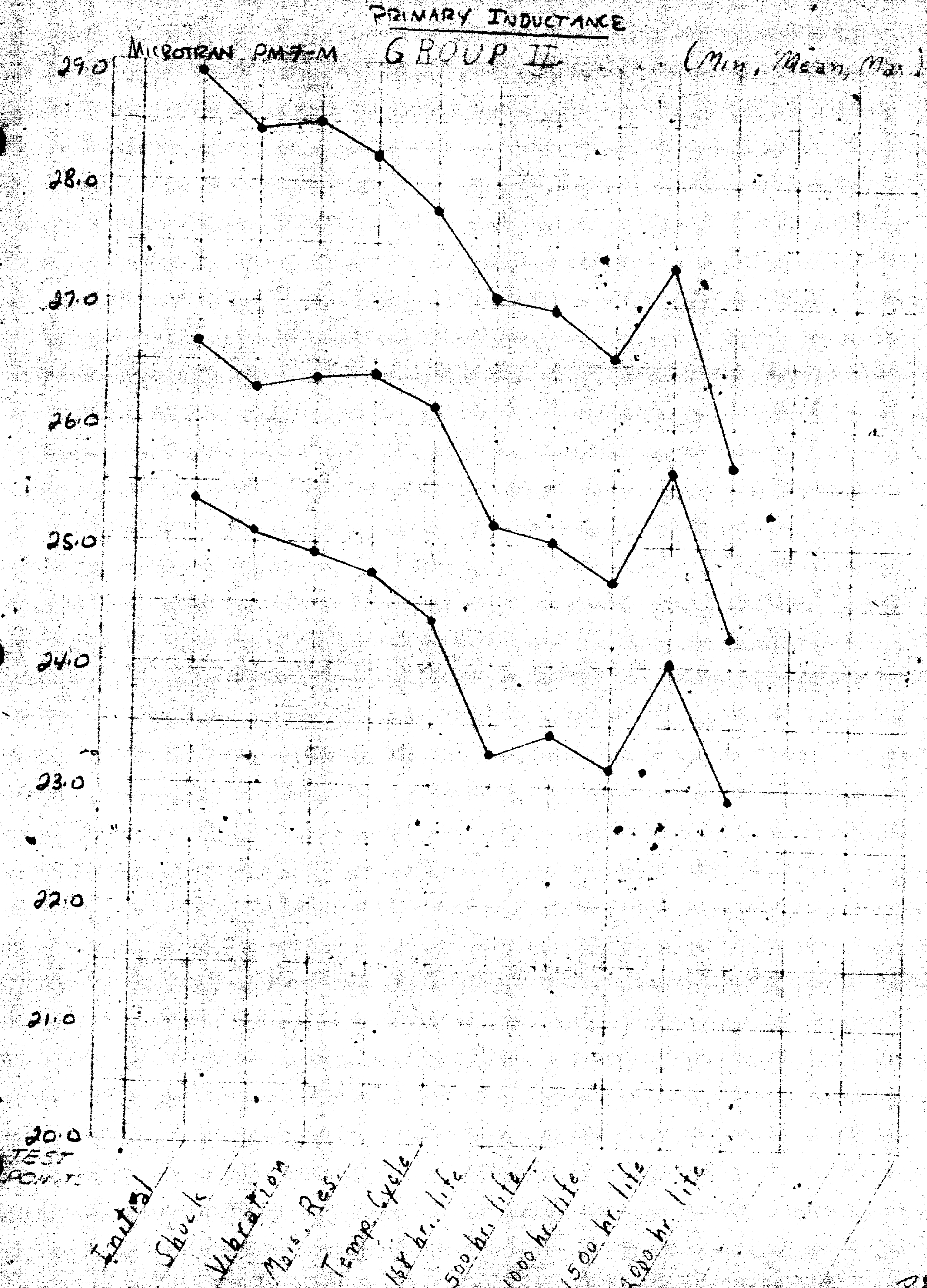


Primary Inductance
UTC DO-T10 GROUP I
(Min, Mean, Max)
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
TEST POINTS
Initial
Freq Response
Shock
Vibration
Mois. Res.
Temp Cycle
168 hr life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

Primary Inductance

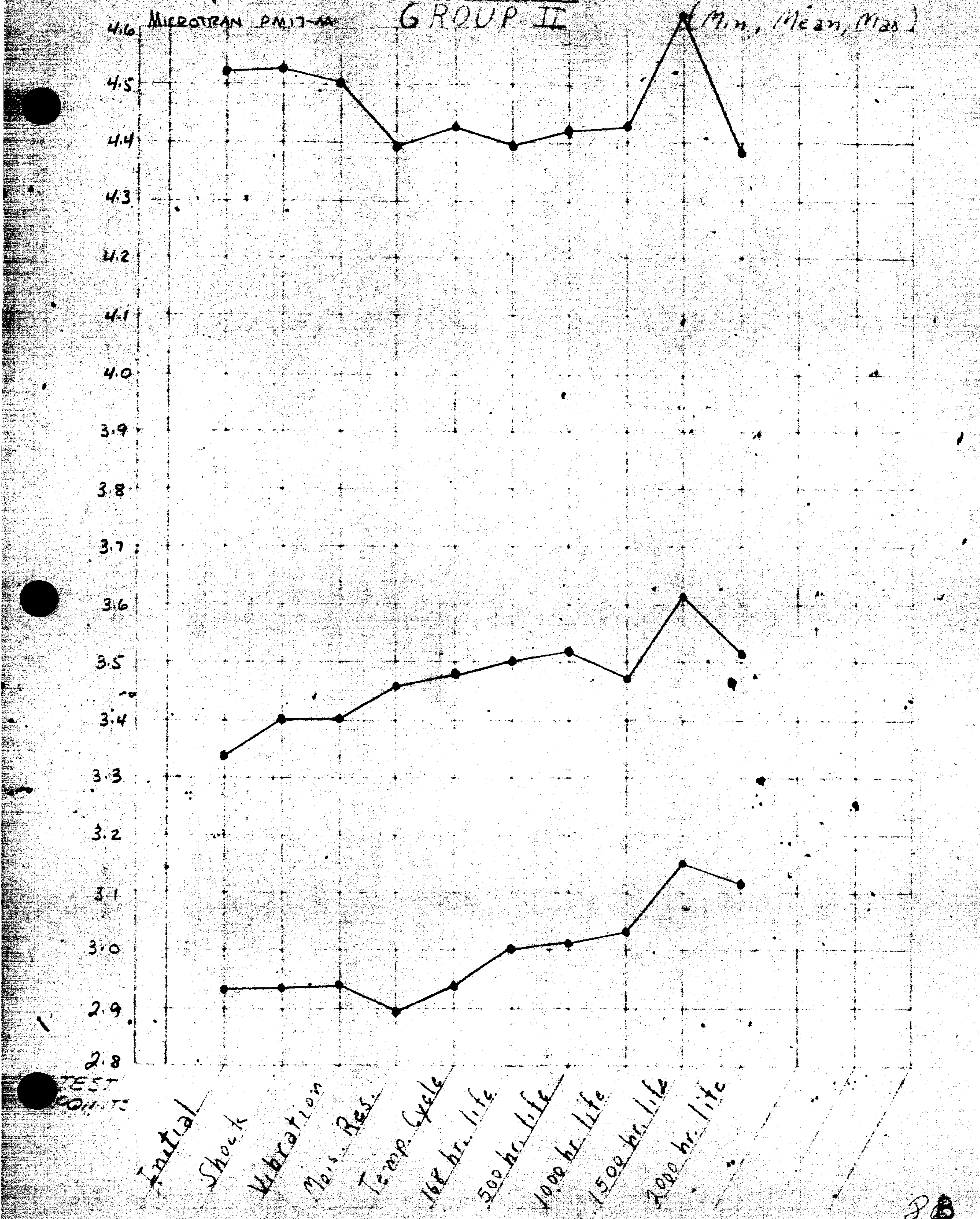
UTC DO-T36 GROUP I (Min, Mean, Max)



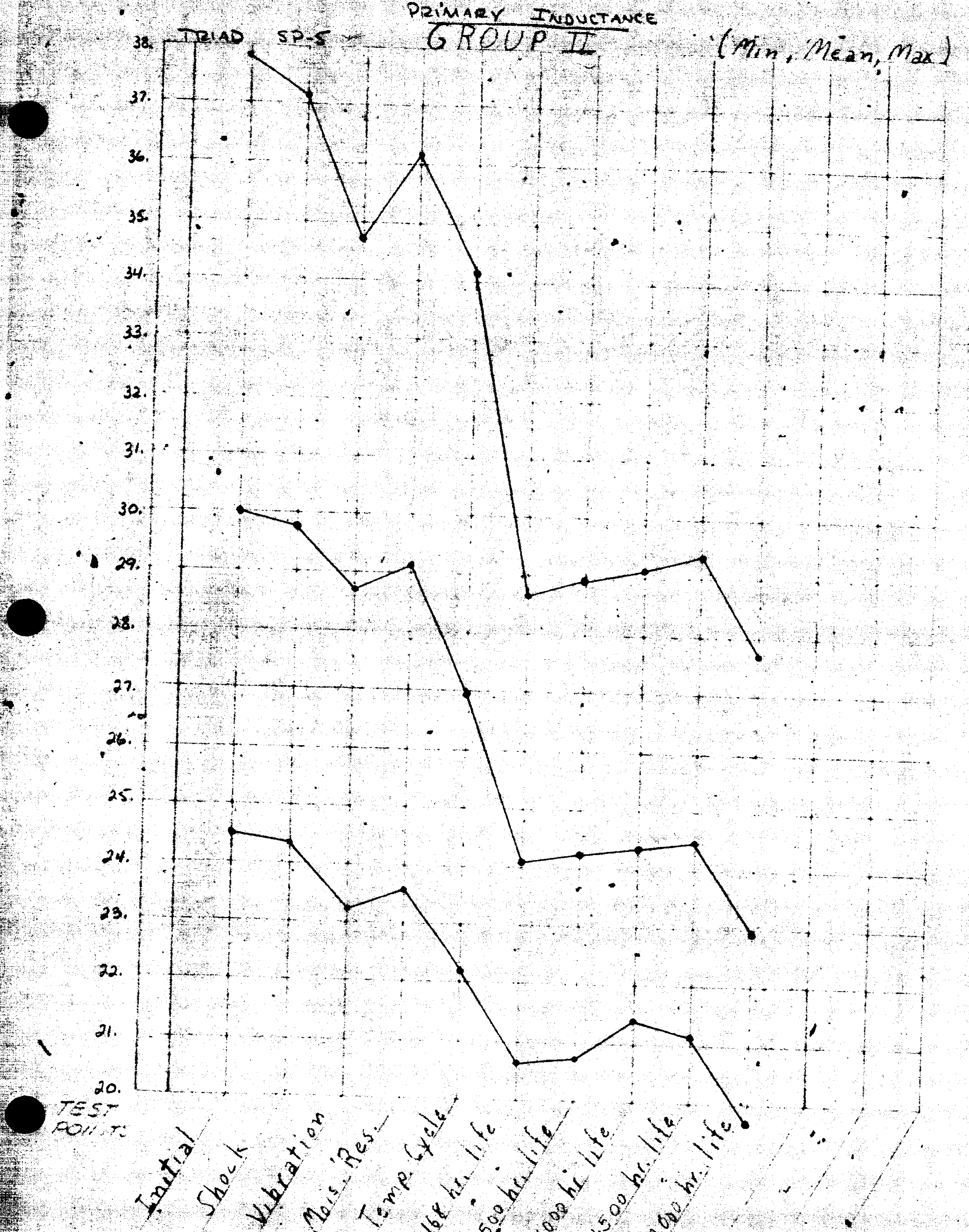


PRIMARY INDUCTANCE
MICROTRAN PM9-M
GROUP II
(Min, Mean, Max)
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hrs. life
1000 hr. life
1500 hr. life
2000 hr. life

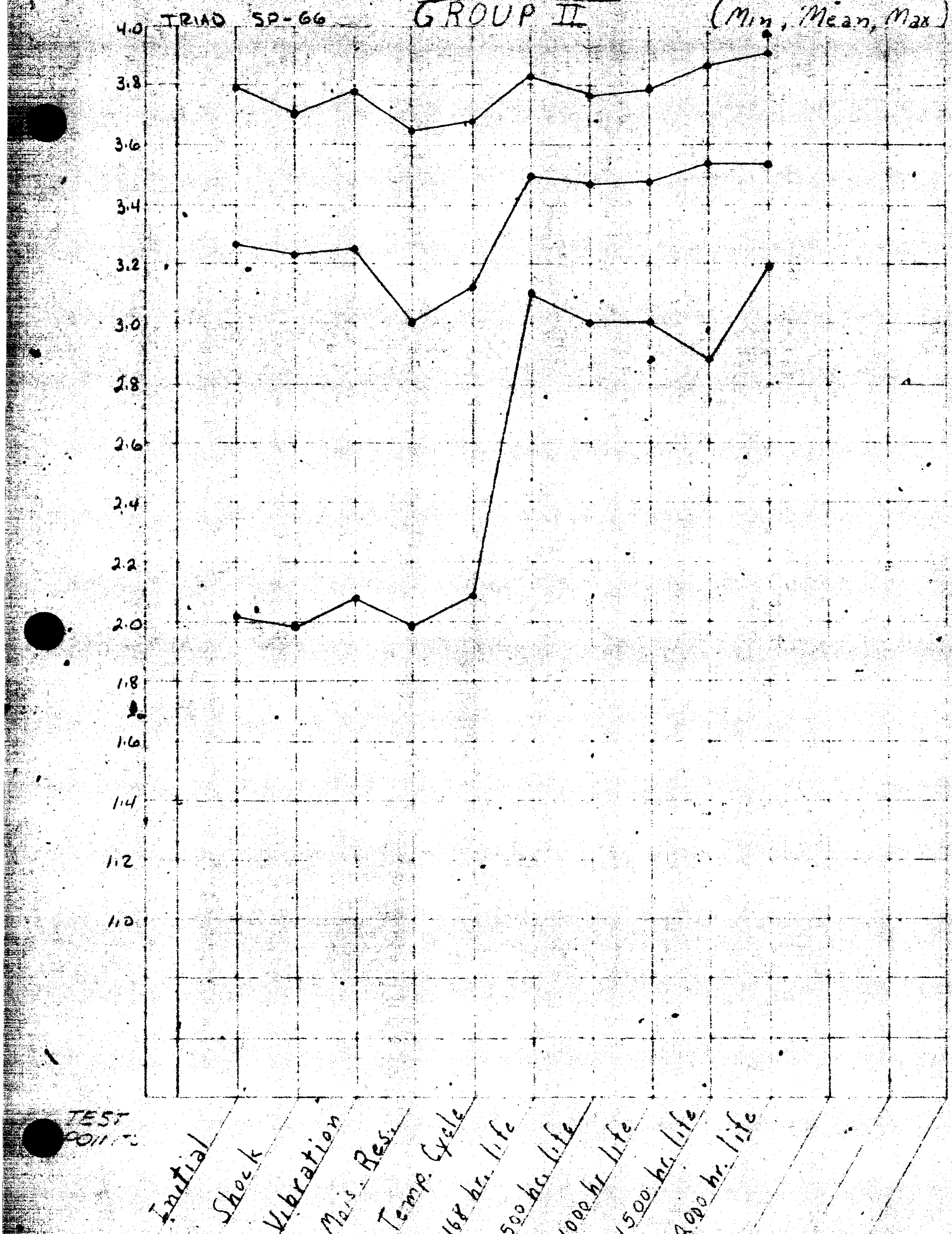
PRIMARY INDUCTANCE



88

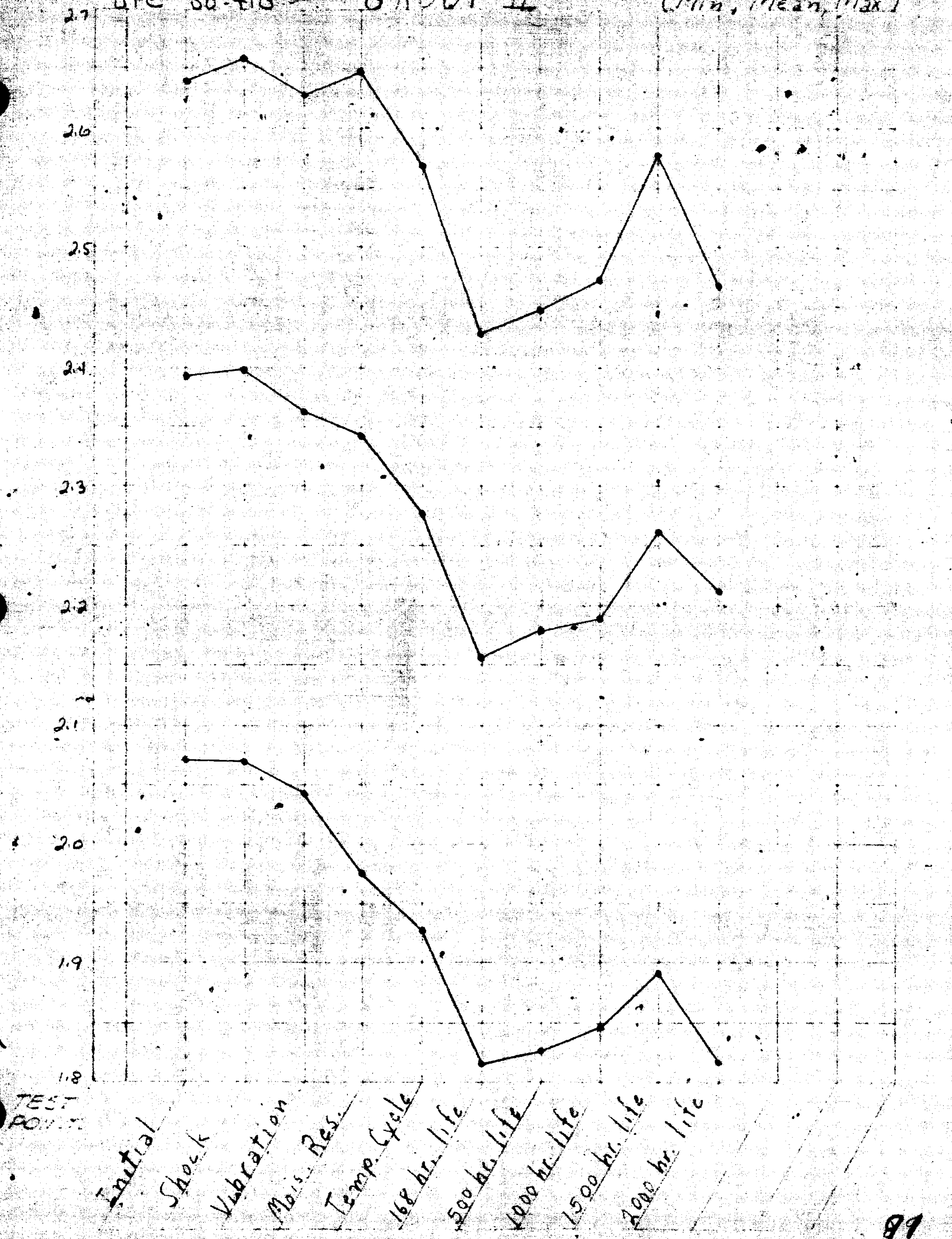

PRIMARY INDUCTANCE
TRIAD SP-5
GROUP II
(Min, Mean, Max)
38.
37.
36.
35.
34.
33.
32.
31.
30.
29.
28.
27.
26.
25.
24.
23.
22.
21.
20.
TEST POINTS
Initial
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

PRIMARY INDUCTANCE



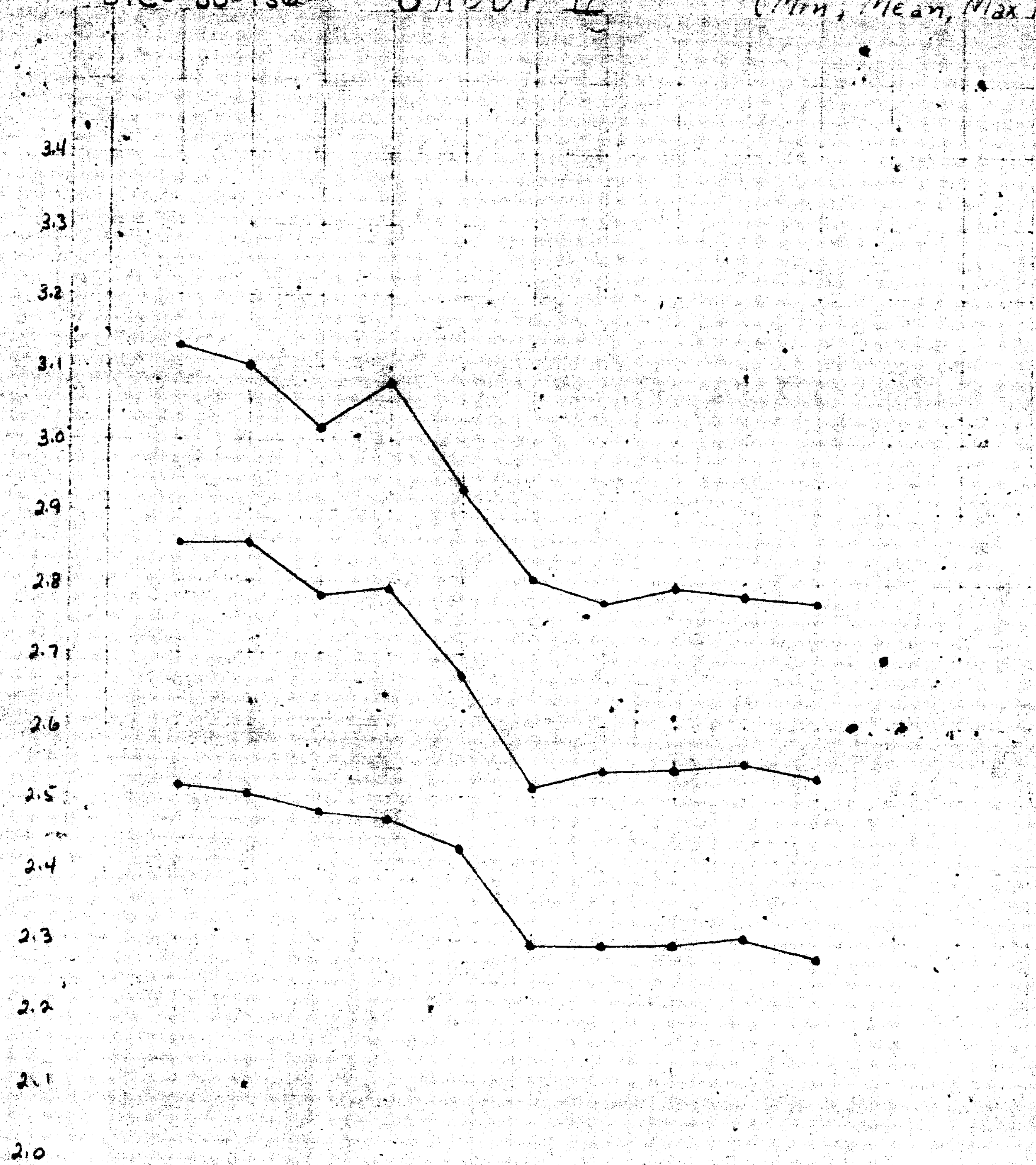
PRIMARY INDUCTANCE

UTC DO-T10 — GROUP II (Min, Mean, Max)



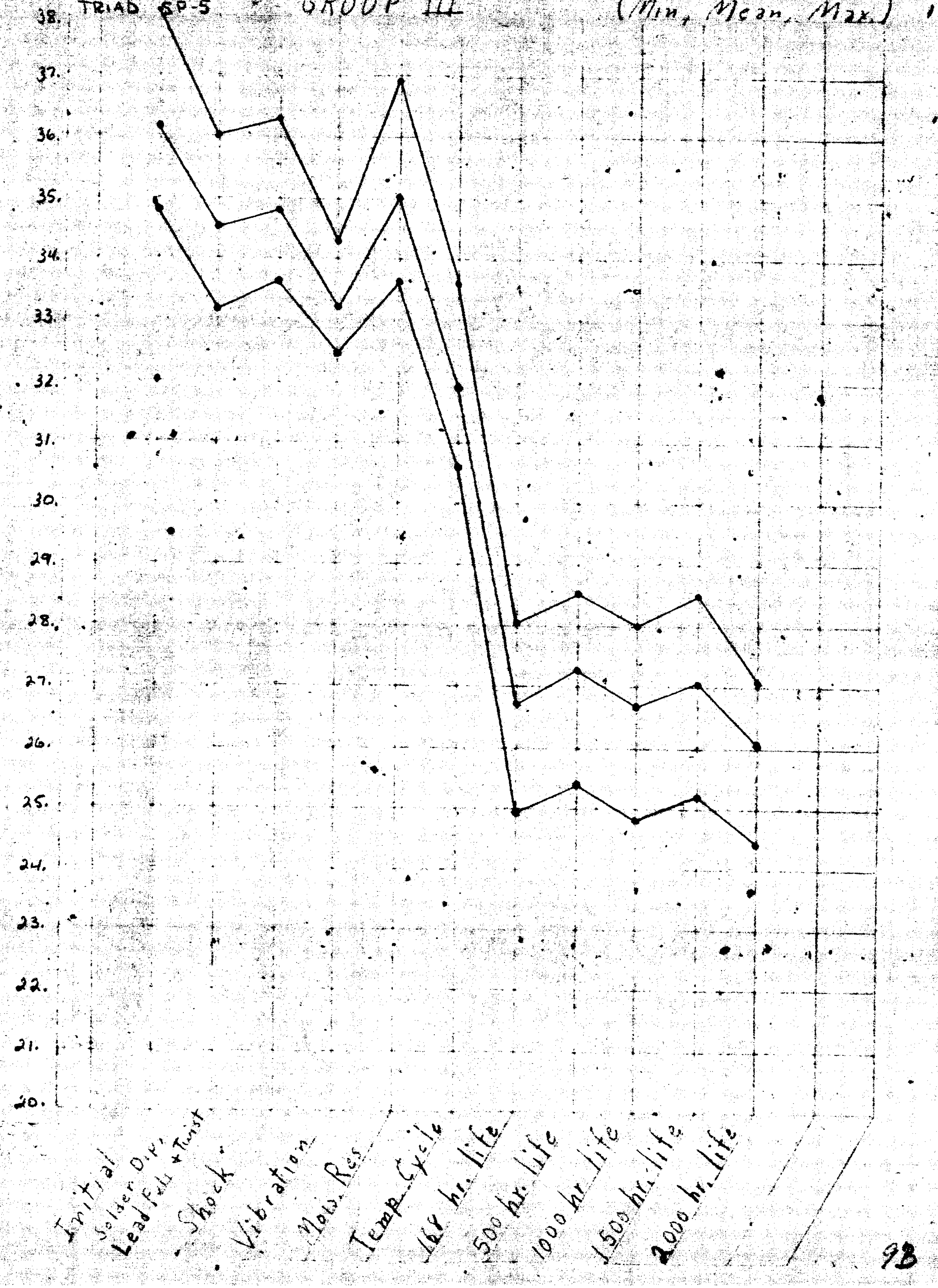
PRIMARY INDUCTANCE

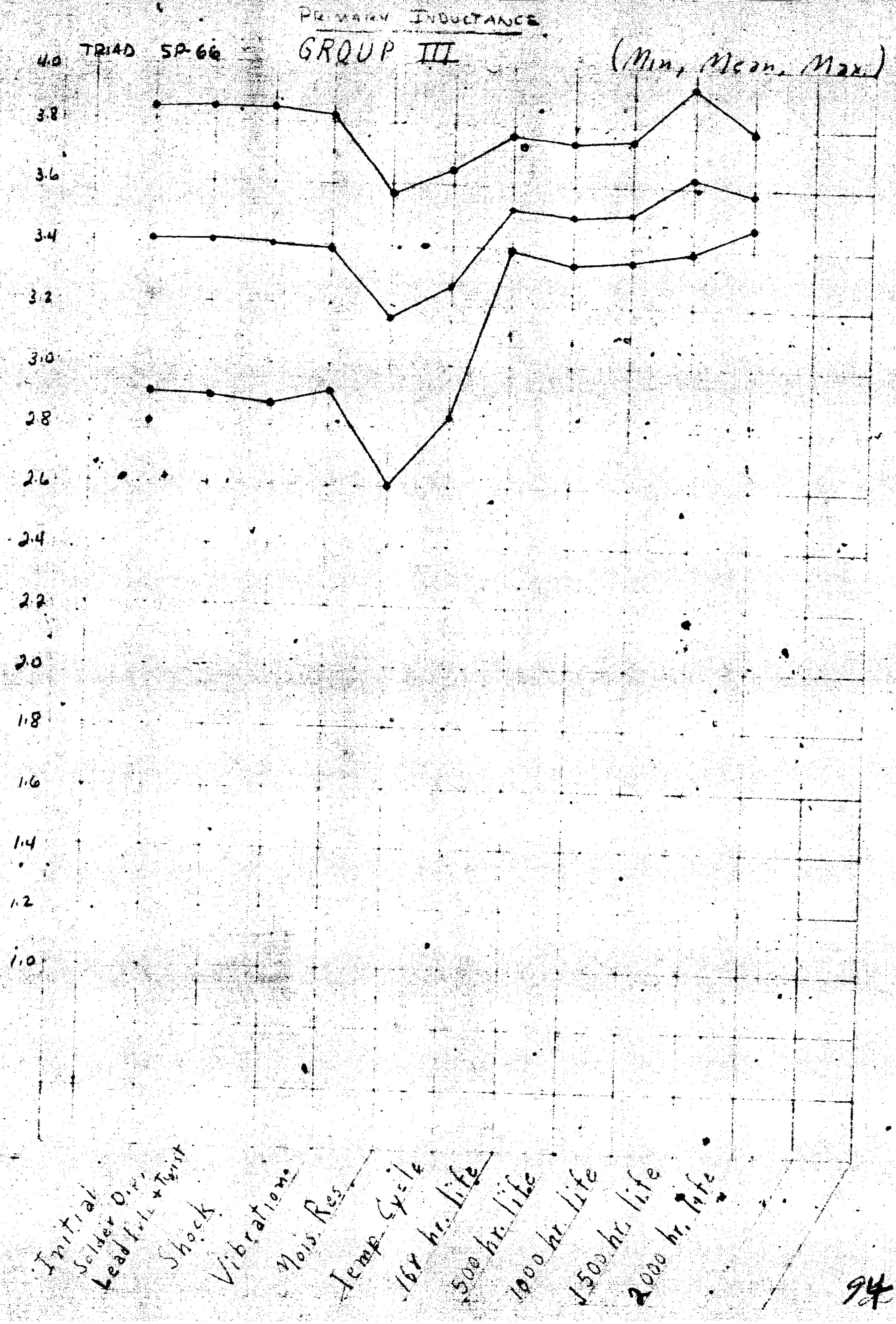
UTC- DO-T36 GROUP II (Min, Mean, Max)



PRIMARY INDUCTANCE

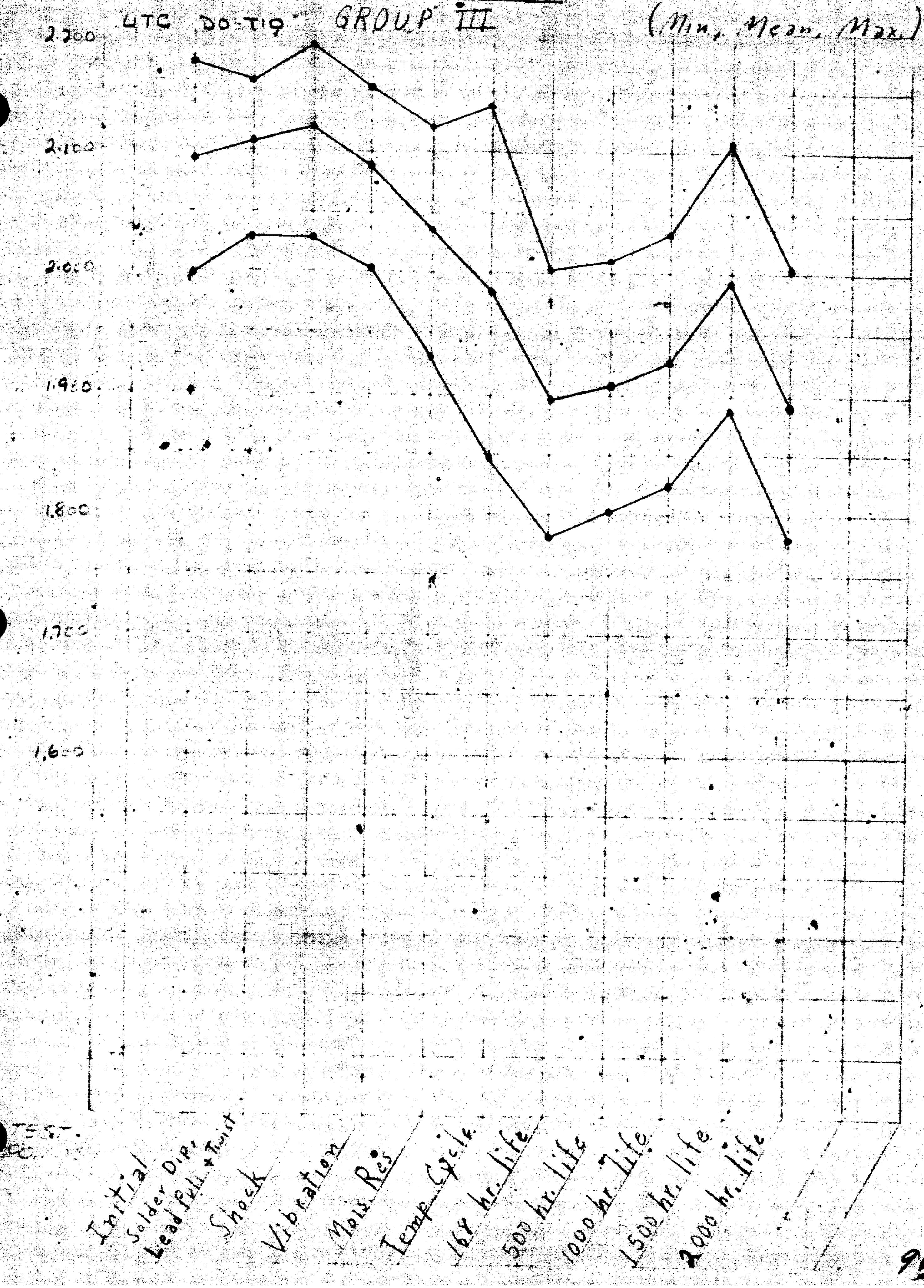
TRIAD SP-5 GROUP III (Min, Mean, Max.)





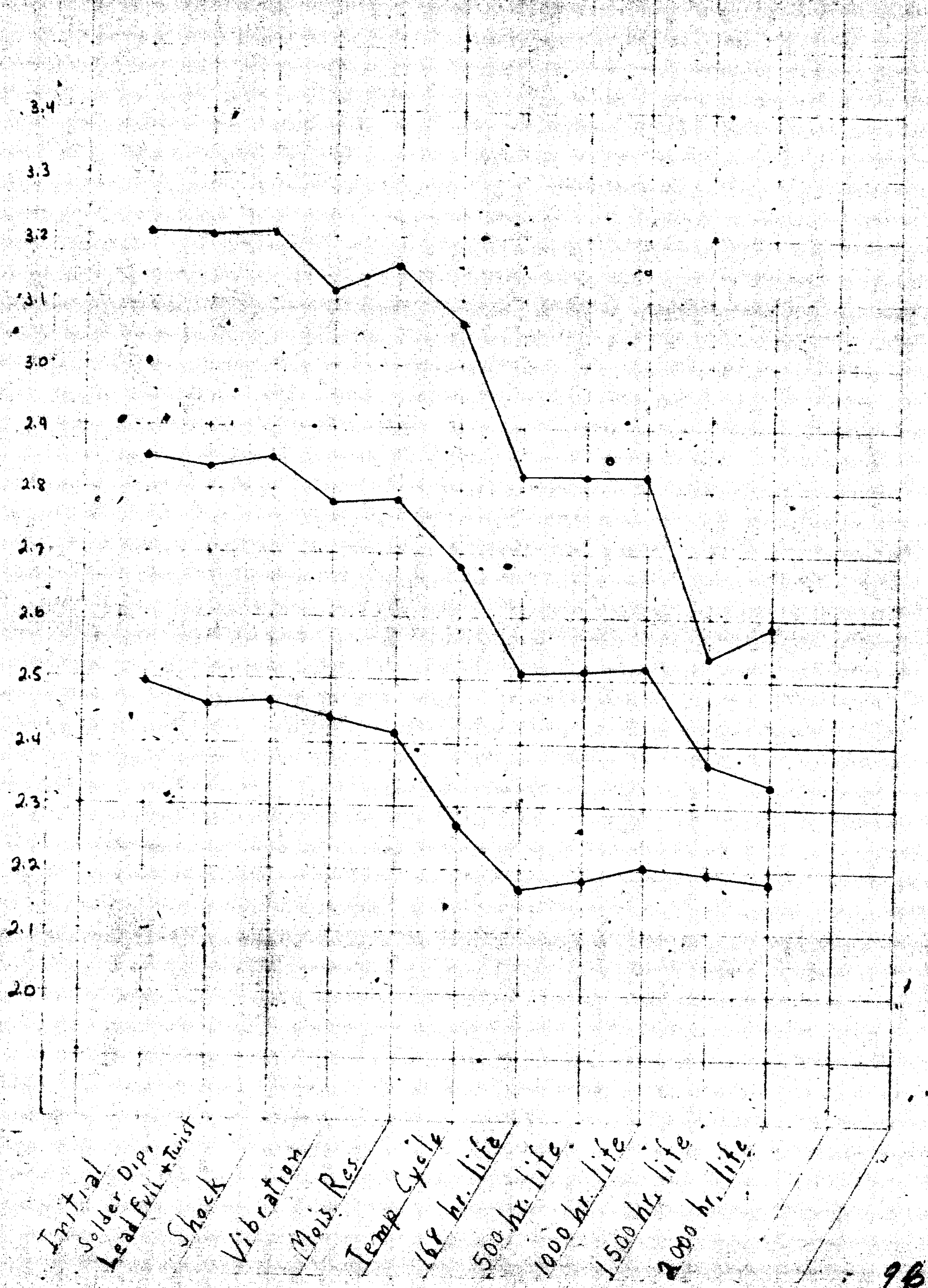
PRIMARY INDUCTANCE
TRIAD SP-66
GROUP III
(Min, Mean, Max)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
Initial
Solder Dip Lead Pull + Twist
Shock
Vibration
Mois. Res.
Temp. Cycle
168 hr. life
500 hr. life
1000 hr. life
1500 hr. life
2000 hr. life

PRIMARY INDUCTANCE



PRIMARY INDUCTANCE

UTC DO-T36 - GROUP III (Min, Mean, Max.)



4.4 Reliability Estimates and Comparisons

4.4.1 Percent of Catastrophic Failures for each and all Environments

4.4.1.1 Group I

Manufacturer	Part No.	Init	Freq Response	Shock	Vib	Mois Res	Temp Cycle	Hi Temp Life	Final
Microtran	PM7-M	0	0	0	0	33.3%	0	0	0
Microtran	PM17-M	33.3%	0	0	0	0	0	0	0
Triad	SP-5	0	0	0	0	0	0	0	0
Triad	SP-66	0	0	0	0	0	0	33.3%	0
UTC	DO-T10	0	0	0	0	0	0	0	0
UTC	DO-T36	0	0	0	0	0	0	0	0

4.4.1.2 Group II

Manufacturer	Part No.	Init	Shock	Vib.	Mois Res.	Temp. Cycle	Hi Temp Life	Final
Microtran	PM7-M	0	0	0	11.1%	0	12.5%	0
Microtran	PM17-M	0	0	0	33.3%	0	16.7%	0
Triad	SP-5	0	0	0	0	0	0	0
Triad	SP-66	33.3%	0	0	0	0	0	0
UTC	DO-T10	0	0	0	0	0	0	0
UTC	DO-T36	0	0	0	0	0	0	0

4.4.1.3 Group III

Manufacturer	Part No.	Init	Solder Dip Lead Bend, Twist	Shock	Vib	Mois Res	Temp Cycle	Hi Temp Life	Final
Microtran	PM7-M	0	100%	0	0	0	0	0	0
Microtran	PM17-M	0	100%	0	0	0	0	0	0
Triad	SP-5	0	0	0	0	0	0	0	0
Triad	SP-66	0	0	0	0	0	0	0	0
UTC	DO-T10	0	0	0	0	0	0	0	0
UTC	DO-T36	0	0	0	0	0	0	33.3%	0

4.4.1.4 All Groups

Manufacturer	Part No.	# of Failures	% of Failures
Microtran	PM7-M	6	40%
Microtran	PM17-M	8	53.3%
Triad	SP-5	0	0
Triad	SP-66	2	13.3%
UTC	DO-T10	0	0
UTC	DO-T36	1	6.7%

4.4.2 Percent of Parametric Failures for each and all environments. (NOTE: The following tables are for parameter code 03, primary inductance. There were no other parametric failures during test cycle.)

4.4.2.1 Group I

Manufacturer	Part No.	Init	Freq Resp	Shock	Vib	Mois Res	Temp Cycle	168HR Life	500HR Life	1000HR Life	1500HR Life	Final
Microtran	PM7-M	0	100%	100%	66.7%	50%	100%	100%	100%	100%	100%	100%
Microtran	PM17-M	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Triad	SP-5	0	0	0	0	0	66.7%	66.7%	66.7%	66.7%	66.7%	66.7%
Triad	SP-66	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
UTC	DO-T10	0	0	0	0	0	0	0	0	0	0	0
UTC	DO-T36	0	0	0	0	0	0	0	0	0	0	0

4.4.2.2 Group II

Manufacturer	Part No	Init	Shock	Vib	Mois Res	Temp Cycle	168HR Life	500HR Life	1000HR Life	1500HR Life	Final
Microtran	PM7-M	11.1%	33.3%	33.3%	12.2%	25%	75%	87.5%	87.5%	77.4%	100%
Microtran	PM17-M	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Triad	SP-5	44.4%	55.6%	44.4%	44.4%	55.6%	66.7%	66.7%	66.7%	66.7%	66.7%
Triad	SP-66	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
UTC	DO-T10	0	0	0	0	0	0	0	0	0	0
UTC	DO-T36	0	0	0	0	0	0	0	0	0	0

4.4.2.3 Group III

Manufacturer	Part No	Init	Solder Dip Bend, Twist	Shock	Vib	Mois Res	Temp Cycle	168HR Life	500HR Life	1000HR Life	1500HR Life	Final
Microtran	PM7-M	66.7%	66.7%	66.7%	66.7%	66.7%	66.7%	66.7%	66.7%	66.7%	66.7%	66.7%
Microtran	PM17-M	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Triad	SP-5	0	0	0	0	0	0	33.3%	33.3%	33.3%	33.3%	33.3%
Triad	SP-66	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
UTC	DO-T10	0	0	0	0	0	0	0	0	0	0	0
UTC	DO-T36	0	0	0	0	0	0	0	0	0	0	0

4.4.2.4 All Groups

Manufacturer	Part No	Init	Shock	Vib	Mois Res	Temp Cycle	168HR Life	500HR Life	1000HR Life	1500HR Life	Final
Microtran	PM7-M	20%	50%	41.6%	20%	40%	80%	90%	90%	77.5%	100%
Microtran	PM17-M	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Triad	SP-5	26.7%	33.3%	26.7%	26.7%	53.3%	60%	60%	60%	60%	60%
Triad	SP-66	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
UTC	DO-T10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
UTC	DO-T36	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

4.4.3 Exponential Failure Rate

Assuming an exponential distribution of failures, the following table presents the catastrophic failure rate in percent per 1000 hours at 90, 60, and 50 percent confidence levels. The analysis was made using a two sided Chi Square confidence interval. Where no failure occurred during life test, no analysis was made.

4.4.3.1 Procedure

The exponential functions is defined as:

$$f(t,\theta) = \frac{1}{\theta} e^{-\frac{t}{\theta}} \quad \text{for } \theta,\ t, > 0$$
$$= 0 \quad \text{for } t \leq 0$$

The two sided confidence interval is given by:

$$\frac{2T}{\chi^2_{\frac{\alpha}{2}(2r+2)}} < \theta < \frac{2T}{\chi^2_{(1-\frac{\alpha}{2})(2r)}}$$

where:

T is the accumulated life time of all components on test.

T is formed by the equation $T = \sum_{i=1}^{k} X_i f_i + (n - r)\, t_t$

r is the total number of failures that occurred during the test period.

n is the number of units tested

t_t truncation time (2000 hrs)

f_i is the number of failures after a given life test measurement.

X_i is the mean life test time (in hours) for a given life test measurement point.

α is given by:

confidence level = $(1 - \alpha)$ 100%

For the exponential distribution the relationship be between mean life θ and the failure rate λ is given by

$$\lambda = \frac{1}{\theta}$$

Catastrophic failure rate in percent per 1000 hours.

Manufacture	Part Number	confidence level	Group I	Group II	Group III	All Groups
Microtran	PM7-M	90%	no failures	$.34 < \lambda < 31.1$	no failures	$.30 < \lambda < 27.5$
		60%	"	$1.46 < \lambda < 19.6$	"	$1.3 < \lambda < 17.4$
		50%	"	$1.89 < \lambda < 13.5$	"	$1.67 < \lambda < 11.9$
Microtran	PM17-M	90%	"	$.48 < \lambda < 44.1$	"	$.35 < \lambda < 32.2$
		60%	"	$2.07 < \lambda < 27.9$	"	$1.51 < \lambda < 20.3$
		50%	"	$2.67 < \lambda < 19.1$	"	$1.95 < \lambda < 13.9$
Triad	SP-5	90%	"	no failures	"	No failures
		60%	"	"	"	"
		50%	"	"	"	"
Triad	SP-66	90%	$1.26 < \lambda < 116.2$	"	"	$.20 < \lambda < 18.2$
		60%	$5.46 < \lambda < 73.4$	"	"	$.85 < \lambda < 11.5$
		50%	$7.04 < \lambda < 50.3$	"	"	$1.1 < \lambda < 7.87$
UTC	DO-T10	90%	no failures	"	"	"
		60%	"	"	"	"
		50%	"	"	"	"
UTC	DO-T36	90%	"	"	$.98 < \lambda < 90.4$	$.26 < \lambda < 16.2$
		60%	"	"	$4.24 < \lambda < 57.0$	$.76 < \lambda < 10.2$
		50%	"	"	$5.5 < \lambda < 39.1$	$.98 < \lambda < 7.02$

4.4.4 Weibull Failure Rate

No Weibull analysis was made due to the lack of sufficient raw data needed for estimating the alpha and beta parameters associated with the Weibull distribution.

5.0 Discussion of the Test Results

All Microtran units that underwent the lead pull and twist test failed. An internal inspection of these units revealed that the potting compound was still soft and that the leads were not sufficiently anchored. With this lone exception, all of the units exhibited very good reliability both physically and electrically. The main objectives of the test program (i.e. determine part reliability) was seriously hampered by the lack of useful raw data obtained. This problem can be largely attributed to the small number of units placed on test (15 from each vendor). The only specimen peculiarity that might have altered the test results was the inability of the Microtran units to successfully complete the lead pull and twist test, further testing of Microtran units in Group III was not possible.

6.0 Conclusions

The basic results of the test appear to be inconclusive with respect to establishing component reliability. The nature of the test was such that the units were subjected to excessive physical handling which they would not normally be subjected to in circuit use. This handling produced failures which cannot be attributed to the test itself and hence affected the validity of the results. A modified test program stressing uniformity of testing procedures and minimizing external factors associated with a testing program would yield more accurate results.

7.0 Recommendations

Not applicable (Ref. JPL Spec. ZPP-2098-GEN para. 3.3.11)

Appendix

1.0 Computed Statistics Sheets

The computed statistics sheets are under separate cover.

2.0 List of Test Equipment

Equipment	Manufacturer	Model No.	Serial No.	Calibration Dates
Accelerometer	Endevco	2215	AJ00	
Auto Cycle Vibrator System	MB	-		
a. Exciter	"	C25H	462	9/15/64
b. Amplifier	"	T666	214	9/15/64
c. Console	"	N572-73	288	9/15/64
Bridge	ESI	250-DA	S-0010	8/24/64 11/30/64 3/2/65
Cathode Follower	Columbia Research Lab.	4000	1516	
Chamber, Humidity	Conrad	FD-36-3	7150	12/15/64
Chamber, Temp.	Conrad	FB-32-3-3	7669 7670	9/15/64 12/15/64 4/21/65
Digital V.O.M.	Cimron	7200A	3037	9/5/64 12/1/64
Diode Resistance Box	Heath	DR-1	0629	
Electronic Counter	Hewlett-Packard	542-D	0665	8/10/64 11/11/64 2/15/65
Megohmmeter	Industrial Instruments	L-7	0194	7/10/64 1/11/65
Milliammeter	Sensitive Research	University	1035	9/9/64 12/8/64 3/12/65
Oven	Blue M	POM-5886C	PA414	9/15/64
Oven	Bemco	DF-100/650-1	1006-1060	9/15/64
Oscilloscope	Tektronix	545	15742	8/10/64 11/23/64
Potentiometer	Gray Inst.	E-3067	18824	9/23/64 8/30/64

Q Meter	Boonton Radio Corp.	260A	0159	11/30/64
Shock Machine	Avco	SM-020 Mod. #1	1009	Calibrated on each as used.
Signal Generator	Hewlett-Packard	200CD	1088	9/9/64 12/4/64

3.0 Log of Irregular Incidents

A review of the test data revealed two mistakes in the CSS.

(1) Page 014, measurement 05, min value should be 898.8, not 98.8.

(2) Page 062, measurement 07, the five max readings should have the decimal point moved one unit to the left.

Corrections will be forwarded when completed.

4.0 Photos and Charts

Photographs of catastrophic failures are attached to the enclosed Failure Analysis Reports.

5.0 Sample Calculations

5.1 Center Tap Unbalance (for a 1:1 unit)

$$C.T.U. = \frac{E_1 - E_2}{E_1} \qquad E_1 = 5.000, \quad E_2 = 4.992$$

$$C.T.U. = \frac{5.000 - 4.992}{5.000} = \frac{.008}{5.00} = .16\%$$

5.2 Frequency Response (for a 1:1 unit)

$$db = 20 \log \frac{E_r}{E_f} \qquad \text{for } E_r = 10.1 \text{ and } E_f = 7.66$$

$$db = 20 \log \frac{10.1}{7.66}$$

$$db = 20 \log(1.318)$$

$$db = 20 \times 0.120$$

$$db = .34$$

5.3 Exponential Failure Rate (for PM7-M, all groups, at 90% level)

test point	test interval	class mark $\bar{X}_i$	failures f_i	$\bar{X}_i f_i$
168	0-168	84	0	0
500	168-500	334	0	0
1000	500-1000	750	0	0
1500	1000-1500	1250	1	1250
2000	1500-2000	1750	0	0
			$r = \sum f_i = 1$	$\sum X_i f_i = 1250$

$T = 1250 + (9 - 1)2000$

$T = 1250 + 16000$

$T = 17250$ $\qquad 2T = 34500$

$r = 1$

$$\frac{34500}{\chi^2_{.05,4}} < \theta < \frac{34500}{\chi^2_{.95,2}}$$

$$\frac{34500}{9.488} < \theta < \frac{34500}{.103}$$

$$3636.17 < \theta < 334951$$

$$.00000298 < \lambda < .000275$$

$$.30\% < \lambda < 27.5\% \text{ failures per 1000 hours}$$